THE DECEMBER SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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RECENT BOOKS OF SCIENTIFIC INTEREST

with comments by the publisher

The Story of Chemistry. FLOYD L. DARROW. 496 pp. $4.00. The Bobbs Merrill Company, Indianapolis.

The development of chemistry from the days of the alchemist to the present time. Enough of the underlying principles are given to enable the general reader to follow the subject. Illustrated.

The Cliff Dwellers of Kenya. J. A. MASSAM. 261 pp. Lippincott & Company, Philadelphia.

An account of a people driven by raids and famine to take refuge on the inaccessible ledges of precipitous mountains, with a description of their ways of living. It is written by the district commissioner of the Kenya Colony.

Mendelism. REGINALD PUNNETT. 231 pp. Macmillan & Company, London.

This work describes Mendel's fundamental work in the modern science of heredity. Written in a more or less technical fashion. Some of the chapters are: Historical; Mendel's Work; Interaction of Factors; Sex-Linkage; Sex and Intersex; Certain Complications; Man.

Speaking with Tongues. GEORGE BARTON CUTTEN. 184 pp. $2.50. Yale University Press, New Haven.

A historical and psychological consideration of the phenomenon of speaking with tongues, which is the first book on this subject in the English language. The chief inspiration of the book was found in the study of the historical development of the Christian Church.

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A symposium by leaders in scientific fields, discussing the relations of the mind to biology, philosophy, education, anthropology, sociology and aesthetics.

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A popular presentation of the science of geology. The history of the earth, its structure, and the forces that work upon it are described with scientific accurateness, but in a non-technical language comprehensible for the layman. Fully illustrated.

The Human Body. LOGAN CLENDENING. 389 pp. $6.00. Alfred A. Knopf, New York.

An account of the anatomy, the physiology and the functions of the human body, presented in untechnical language. It is written for the layman and its purpose is to tell the plain truth about the human body and its health.

Mind and Body. HANS DRIESCH. Authorized Translation by THEODORE BESTERMAN. 176 pp. $3.00. The Dial Press, New York.

This book discusses essential problems of psychology and philosophy. The first part is a critique of psychophysical parallelism; the second part deals with the relations between the mind and body of man.

The Story of Geology. ALLAN L. BENSON. 297 pp. $4.00. Cosmopolitan Book Corporation, New York.

This work presents the facts which underlie modern theories of the earth's origin and evolution. It is especially prepared for the general reader and contains many interesting illustrations.

Heredity and Human Affairs. EDWARD M. EAST. 312 pp. $3.50. Charles Scribner's Sons, New York.

This volume serves as a simple introduction to the principles of genetics and shows how this science may be used in analyzing important social questions. It is written for the non-specialist.

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DECEMBER, 1927

SMELL AND TASTE AND THEIR APPLICATIONS

By Dr. N. E. McINDOO
WASHINGTON, D. C.

IS THERE A SCIENCE OF SMELL OR OF TASTE?

THE late Alexander Graham Bell, when once consulted about the physicochemical possibilities of odors, remarked that an odor had already made one man famous. He asked who was ready to evolve a new science, by measuring or reflecting a smell. He said in part:

> Have you an ambition to found a new science? Why not measure a smell? Can you measure the difference between one kind of smell and another? Until you can measure their likenesses and differences you can have no science of odor. Find out what an odor is—whether it is an emanation, and therefore subject to being weighed, or a vibration, and therefore capable of being reflected. Odors are becoming more and more important in the world of scientific experiments and in medicine—and the need of more knowledge will bring more knowledge, as surely as the sun shines.

Regardless of the above admonition that we do not yet have a science of smell, Kenneth, a Scottish professor in the University of Edinburgh, has listed 1,000 references on "Osmics: The Science of Smell," and makes the following remarks:

> Smells are surer than sounds to make the heart-strings crack, yet, owing to a lack of training, one is not always aware of the fact that one lives in a world of smell as well as in a world of form, color and sound. However, the knowledge of the organs and the sense of smell, and of odorous substances, is recorded in a voluminous and widely scattered literature. Some day, perhaps, a special Institute of Osmics will be established, where research could be coordinated. The staff would comprise at least a physiologist, psychologist, chemist, zoologist, botanist, anthropologist, pathologist, rhinologist and statistician, and would also require the services of an embryologist, geneticist and a paleontologist.

What next! No wonder so little has been accomplished on this subject, if in order to obtain results such an extensive collaboration is really necessary! Yet when we carefully examine our records we are convinced that more cooperation between the various groups of scientists interested in this subject is absolutely necessary before we can actually found a new science as outlined by Dr. Bell.

According to Kenneth:

> Briefly, osmics is a science of the stimuli, organs and the sense of smell. It is evident, therefore, that this area of science is fundamentally a rendezvous of chemistry, physics and biology in the widest sense.

The word "osmics" comes from a Greek word, meaning odor; and Kenneth is so enthusiastic about encouraging the foundation of a science of smell, which really involves the deepest studies in botany, zoology, chemistry and physics, that he imagines that the results obtained will aid research on the nature of matter.

Another enthusiastic scientist, a chemist, who is encouraging research in the sense of smell, is Hendrick. He says:

> It is remarkable how intimate the sense of smell is, how much it tells us, and how largely it affects consciousness on the one hand, and how we scorn consideration of it on the other. It is the Cinderella of our organs of sense. Whether it was some sainted anchorite, or other enthusiast of imagination and influence, who found the use of the human nose to be dangerous to the soul, we do not know, but in some way or other the conscious exercise of the nose became taboo, and this has entered into the folk-ways. It has ceased to be a sin, but it remains an impolite subject.
>
> The Arabs in their days of glory were not ashamed of their noses, and they planted scented gardens, wonderfully devised, so that he who walked through them, or whiled away an hour there, might rejoice in a cultured delight in odor. They were so arranged that at the entrance the olfactory sense would be struck by a pervading and strong smell, not necessarily of a pleasant nature. From this the path would lead gradually through less coarse fragrances to those more delicate until, at the end, there would be reached an odor of exquisite quality which only the cultured nose could appreciate.
>
> Just think what we owe to our eyes and ears! Through them we gain nearly all of our knowledge. They are trained so that by them we read books and hear speeches, we note anger, deceit, joy, love; by sight and hearing we try to guess faithfulness and malice; in fact, through these two senses we draw the substance of our information. And yet we are said to have five senses. Neither touch nor hearing nor sight is within the scope of this paper, and taste is a limited sense, alive only to sweet, sour, bitter and a few simple nerve-reactions. Owing to the taboo of smell we have credited to taste most of those olfactory processes which we have cultivated. It is smell of food that we enjoy while we are eating it; it is the bouquet of a wine that gives it its merit. We call it the taste, but it is chiefly the smell. It is nearly impossible, for instance, to distinguish between what we call the taste of cinnamon and that of cloves if we hold our noses.

The theories of smell and taste, as given, are very vague, and, in comparison to sight and hearing, very little fundamental work has been done on them. In this respect we are still living in the Dark Ages, and have not progressed much since the "glorious" days of the Arabs. Good work has been done, but not enough; and enough will not be done till there obtains a lively and wholesome curiosity about these two neglected senses, which in reality must be studied together, for they can not be sharply separated.

On the other hand, consider what illuminating results are now available from researches in some of the other senses. To illustrate the comparative attention devoted to the different senses, one needs only to open a book of reference, such as the Encyclopædia Britannica. In the last edition of this work, dated 1926, over thirty-two pages are devoted to sound, seventeen and a half to light, and four to touch, but only a page and a half each to smell and taste. The authors of this storehouse of knowledge have either carelessly overlooked the recent information on all the five special senses, except sound, or they consider it of too little merit to be published in the 1922 and 1926 supplements. As the World War aroused a lively interest in sound-detecting devices, ten pages about sound have been added in the last two supplements. Light has been ignored, although the subject of illuminating devices, which does not belong to our discussion of senses, has been brought up to date. One is not surprised to know that the part played by smell in this war has been omitted, for information on this topic is widely scattered and is of less importance than that about the part played by sound and light.

Speaking about the senses, how many do we have? Every one knows about the five special ones, and many of us are aware that we have other senses, called the general senses but how many? Herrick tells us that we have, in reality, more than twenty different senses. Hearing, sight and touch are called the physical senses, and the first two are truly measurable, because their stimuli —sound waves and light waves—have

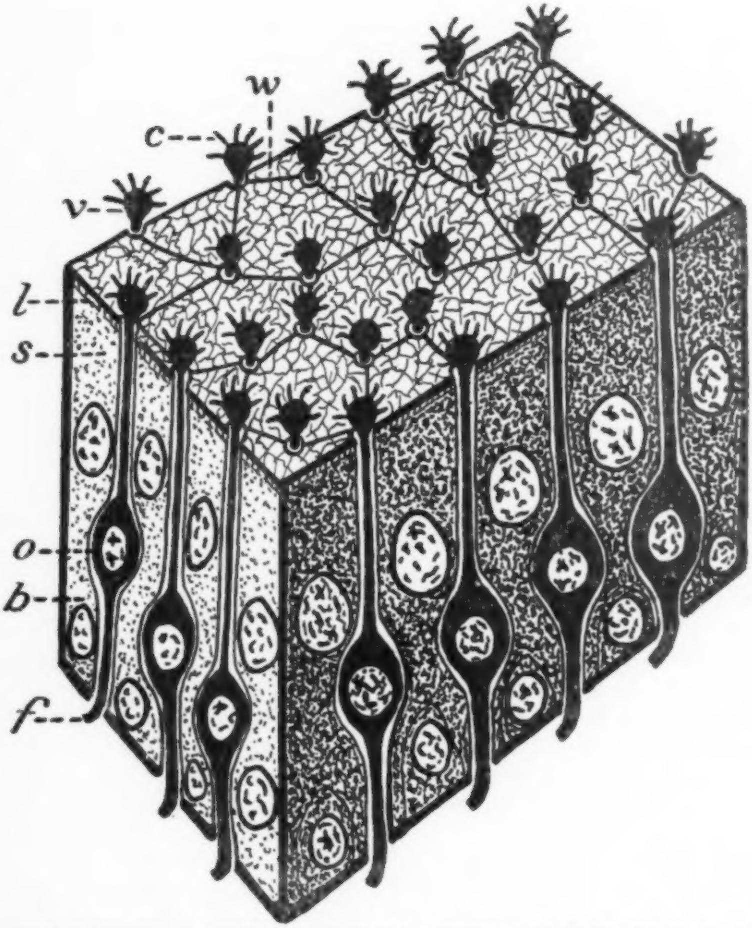

FIG. 1. DIAGRAM OF A BLOCK FROM THE OLFACTORY MUCOUS MEMBRANE OF A KITTEN

SHOWING IN SECTION AND PERSPECTIVE THE FOLLOWING: BASAL CELLS (*b*), OLFACTORY CILIA (*c*), NERVE FIBERS (*f*), LIMITING MEMBRANE (*l*), OLFACTORY CELLS (*o*), SUPPORTING CELLS (*s*), OLFACTORY VESICLES (*v*), AND WALLS (*w*) OF THE FIVE- AND SIX-SIDED SUPPORTING CELLS FROM A SURFACE VIEW. THE OLFACTORY VESICLES AND CILIA, WHICH ARE EMBEDDED IN AND SUPPORTED BY AN OUTER SEMIFLUID (NOT SHOWN IN DRAWING), ARE THE TRUE RECEPTORS OF SMELL. (REDRAWN FROM VAN DER STRICHT'S PHOTOMICROGRAPHS AND FIGURE 36, THE LATTER IN HERRICK'S BOOK.)

been accurately measured and analyzed. As a result of all the thorough study of their stimuli, new worlds have been opened to us; in sound, by the use of the telegraph, telephone, microphone and radio; and in light, by the microscope, telescope, photographic camera and moving picture machine, and by bringing to our aid ultra-violet rays, X-rays and radium. In the light of all this exact knowledge, are we not justified in calling hearing and sight true sciences? But how about smell and taste? We call them chemical senses, because chemicals in one form or another serve as their stimuli. Un-

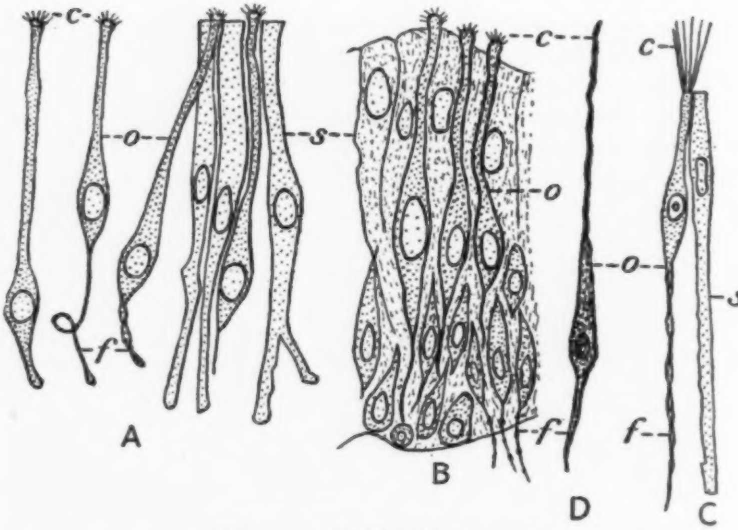

FIG. 2. OLFACTORY CELLS

OLFACTORY CELLS (*o*) AND THEIR CILIA (*c*), AND THEIR SUPPORTING CELLS (*s*), FROM PARKER. A, FROM MAN (AFTER VON BRUNN); B, FROM PIG (AFTER ALCOCK); C, FROM FROG (AFTER SCHULTZE), AND D, FROM A FISH (AFTER JAGODOWSK).

fortunately, however, the character of this stimulation has as yet defied thorough analysis and we have not learned how to weigh or measure its extent or intensity. It can not be said, therefore, that there is a true science of smell or of taste.

When we consider the uses of smell in connection with food-getting and recognition among animals; when we appreciate how a knowledge of smell and taste in noxious insects aids us in our efforts to control them, and when we think of our own uses of these senses in medicine, perfumery and esthetics, and of the importance to our digestion and health of using them aright, we must realize that taste and smell, particularly the latter, should be more seriously studied. We need the information to be gained in this way. It can be used to our great advantage.

USES OF SMELL AND TASTE IN MAN

It is well known that appetizing odors and pleasant tastes make the mouth "water" by stimulating the salivary glands. This is brought about by one of Nature's reflex mechanisms, the purpose of which, in this case, is to welcome food to the mouth and begin its digestion there before it is carried to the stomach. Physiologists tell us that what is true for the salivary glands is equally true for the gastric glands in the stomach, and that the latter are fully as susceptible to gentle suggestions from the olfactory organs. It has been shown experimentally that smell and taste bring about the first processes in digestion. Niles says:

> Let us not, therefore, deem unimportant this humble faculty of smell, which, though modest, is always alert and discriminating, and whose influence over the whole digestive system is becoming more and more appreciated.

Disagreeable odors, from the viewpoint of sanitation and the problem of eliminating them, cause the public health officer much concern. There is a wide-spread belief that foul-smelling odors cause disease. This is not necessarily so, for to-day we can not ascribe any known disease to odor. The sources

of bad odors, nevertheless, may become breeding places for germ-carrying organisms, and of course these require investigation. Then, too, although bad odors from a cesspool do not necessarily result in organic disease and its attendant physical suffering to those exposed to them, they will cause mental suffering unless the nuisance is soon abated, and often this is worse.

Fumes emitted on a large scale from fermenting and putrefying substances have been reported, in certain cases in France, as injurious to health. When we are dealing with poisonous gases, some of which are odorous, the results on health are sometimes serious and even fatal. Other gases, not necessarily fatal or even dangerous in themselves, sometimes serve as warnings of danger from similar sources. A smell of sewer gas may suggest a polluted water supply, and the odor of coal gas may suggest the presence of the inodorous carbon monoxide, which often proves fatal in closed garages and elsewhere. It has been found advisable to add odorous impurities to our manufactured illuminating gas as a safeguard against gas poisoning through carelessness. It is therefore literally true that our lives are often saved by means of our noses.

Odors are often put to various industrial uses, as in the detection of leaks in boilers and pipe lines. For this purpose the oils of peppermint and wintergreen are generally used, mixed with water or air, and then forced through the pipes and boilers; then by smelling at the cracks and joints, leaks can easily be located. A more accurate method is to use catnip oil and then to let a cat locate the leak. Furthermore, experiments have been conducted in the use of odors as warning signs in mines.

In the practice of medicine the physician is using his nose more and more as an aid in diagnosis and medical writers tell us that, if for no other reason, the sense of smell should be cultivated for this purpose. Certain diseases have characteristic smells, and the sense of smell may with good reason be considered of medico-legal importance.

Bacteriologists use their noses in detecting the characteristic odors of cer-

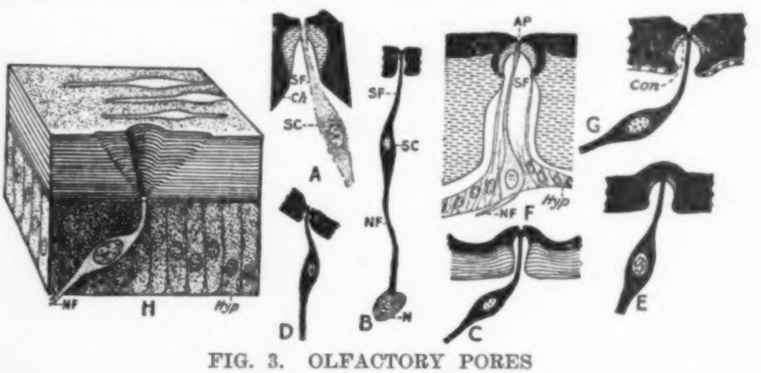

FIG. 3. OLFACTORY PORES

SHOWING INTERNAL STRUCTURE (A TO G) OF INSECTS AND LYRIFORM ORGANS OF SPIDERS (H). A, FROM LEG OF A HONEY-BEE; B, FROM ELYTRON OF A BEETLE; C, FROM A LEG OF A LADY-BEETLE; D, FROM SECOND ANTENNAL SEGMENT OF A GRASSHOPPER; E, FROM WING OF A SILKWORM MOTH; F, FROM ANTENNA OF A BEETLE LARVA; G, FROM MAXILLARY PALPUS OF A TOMATO WORM, AND H, A DIAGRAM REPRESENTING A BLOCK FROM LEG OF A SPIDER, SHOWING SURFACE VIEW OF THREE LYRIFORM ORGANS AND ONE IN SECTION. THE CHITIN (*Ch*) OR CUTICULA IS SHOWN BY SOLID BLACK IN ALL THE FIGURES, EXCEPT C, F AND H; IN C AND F ITS TWO LAYERS ARE REPRESENTED. *AP*, PORE APERTURE; *Con*, CHITINOUS CONE; *Hyp*, HYPODERMIS; *N*, NERVE FIBER; *SC*, SENSE CELL, AND *SF*, SENSE FIBER.

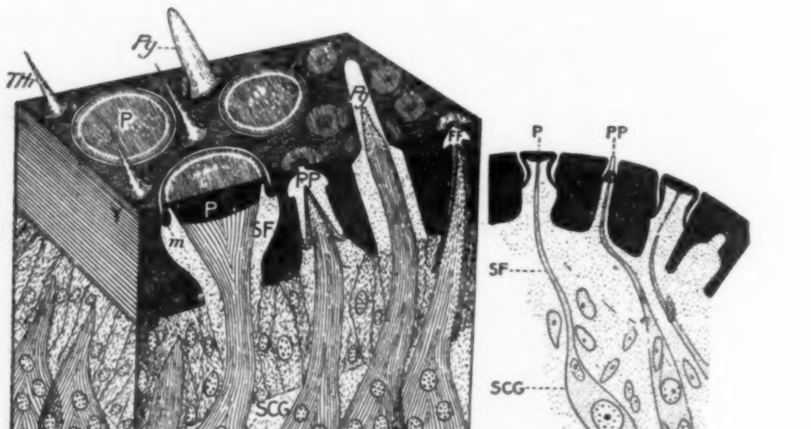

FIG. 4. EXTERNAL AND INTERNAL STRUCTURE OF ANTENNAL SENSE ORGANS MOST OF WHICH ARE CONSIDERED SMELLING ORGANS. A, DIAGRAM REPRESENTING A BLOCK FROM TIP END OF ANTENNA OF A WORKER HONEY-BEE, SHOWING TOUCH HAIRS (*THr*), PEGS (*Pg*), PIT PEGS (*PP*), FOREL FLASKS (*FF*), AND PORE PLATES (*P*) IN BOTH PERSPECTIVE AND SECTION. *Note.*—THE MANNER IN WHICH THE SENSE FIBERS (*SF*) JOIN THE PLATES AND HAIRS IS DIFFERENT FROM THAT FIGURED BY MORE RECENT OBSERVERS, BUT IN EVERY CASE THE FIBER IS SEPARATED FROM THE OUTSIDE AIR BY A LAYER OF CUTICULA. B, LONGITUDINAL SECTION THROUGH AN ANTENNA OF A WATER-BEETLE, SHOWING TWO PORE PLATES (*P*), A PIT PEG (*PP*), SENSE CELL GROUP (*SCG*), NERVE FIBER (*NF*), AND SENSE FIBER (*SF*). (AFTER HOCHREUTHER.)

tain cultures, and chemists are constantly using their olfactory organs as a help in analysis.

As we all know, industries of vast importance have been based on the knowledge of the senses gained through scientific investigation, and these industries, in many cases, have grown to such proportions that they have dwarfed, in the public mind, the sciences that gave them birth. As examples might be mentioned the telephone industry, based on the sense of hearing and the science of acoustics, and the moving-picture industry, based on the sense of sight and the science of optics. The perfume industry, also, based on the sense of smell, has grown to such proportions that the perfumers have included the subject of smell as a part of their business, forgetting that their industry belongs to smell and not the reverse! "How's that?" they may say. "Perfumes are made to be smelled," we reply, "and had man been created without a smeller there would have been no perfume industry, involving millions of dollars and employing thousands of people, ranging all the way from day laborers to the most highly trained organic chemists." Besides stimulating researches in chemistry, botany, zoology, physics, and even anthropology, the perfume industry has opened up a special line of agriculture

devoted to the growing of many plants which would not otherwise have been produced. It should be stated also that in the endeavor to produce highly perfumed flowers many of our cultivated plants highly prized for their color have resulted. The subject of perfumery in all its phases is so large that volumes have been written on it, and its history, including that of cosmetics and soaps, which accompany perfumes, reaches into the remote past. How many users of perfumes and cosmetics to-day are aware that they are still slightly in debt for their personal attractiveness to the efforts of early civilized man, particularly the early Egyptians? This part of the story reads like a romance but can only be mentioned here.

Acuteness of Smell in Man

Literature contains a number of references to the remarkable acuteness of the sense of smell in the aborigines of various countries. The smelling power of these primitive peoples is inconceivable to the average civilized person, and consequently the reader may believe or disbelieve these reports as he likes.

Ethiopians and North-American Indians have a remarkably keen sense of smell, which in part accounts for their wonderful power of trailing their enemies. An old history of the Antilles assures us that some of the Negroes there can, by smell alone, distinguish the footsteps of a Frenchman from those of one of their own race. We are told that the cannibals and snake-eating tribes of Queensland by smell alone hunt and find a large species of boa upon which they live. Lumholz, the observer in this case, with his nose to the ground, could not distinguish the odor which these tribesmen were following with ease. Darwin cites the observations of Humboldt, who reported that certain Peruvian Indians could follow a trail by scent as reliably as a hound. Another writer asserts that he repeatedly conducted experiments which proved that Negroes and Indians recognize persons in darkness by their odors.

In civilized man the sense of smell is most highly developed in the blind. A boy, James Mitchell, was born blind, deaf and dumb, and depended chiefly on smell for keeping himself in touch with the outer world. He readily observed the presence of a stranger in the room and formed his opinions of persons apparently from their characteristic smells.

One writer claims that every individual has his or her own odor, as distinct and personal as is his countenance. As is well known, a dog can easily distinguish these odors, and by them can tell one person from another. We constantly exude products of metabolism through the skin and, since these products always differ, no two of us are alike in regard to odors emitted. Another writer remarks that a person is generally unable to appreciate the differences in odor of the secretions of the skin under different strong emotions, although there is abundant evidence that the nature of these secretions is modified by emotions. What a different world we should live in if the nose could analyze the various emotions so that we could easily distinguish sincerity and sanctity from deceit and villainy! A third writer has devoted a whole chapter to "smell and the personality," and believes that a person's odor has much to do with his personality. He says he is acquainted with English people who are able to recognize by smell not only different races and two sexes, but even different persons. One of these supersensitive acquaintances states that to her the odorous atmosphere of a person is every whit as characteristic and unmistakable as is the play of features or the carriage of the figure. A fourth writer remarks that the African native has a disagreeable smell to the nostrils of the European,

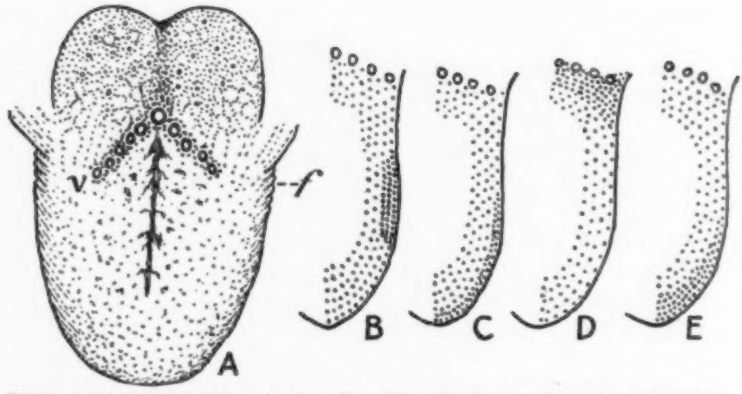

FIG. 5. THE LOCATION OF PAPILLÆ AND TASTE ORGANS ON THE HUMAN TONGUE

A, DORSAL VIEW OF TONGUE, SHOWING FOLIATE PAPILLÆ (*f*) AND VALLATE PAPILLÆ (*v*); B, THE SOUR TASTE, CONCENTRATED ON THE EDGE; C, THE SALTY TASTE, CONCENTRATED AT THE TIP AND ON THE EDGE; D, THE BITTER TASTE, CONCENTRATED AT THE BASE, AND E, THE SWEET TASTE, CONCENTRATED AT THE TIP. (ALL FROM PARKER; B TO E, MODIFIED AFTER HÄNIG.)

and that the European is still more offensive to the olfactory sense of a Japanese.

Since no two individuals emit identical body odors, and since the sexes differ in certain respects in their anatomy and physiology, we can imagine that they also differ in odor. Some human beings who have the power to distinguish individuals by smell have described the personal odor as usually agreeable; and often in the case of the opposite sex, as exciting passion. The odors of butterflies and moths play a great part in the courtship of these insects, thereby stimulating the mating instinct. We react, says one writer, to scents in somewhat the same way, and usually for the same reason, although unconsciously. He further claims that sweet scents arouse the mating instinct, and since perfumes are used largely by women, he believes that these have the same effect. His final conclusion is that a sweet scent is one which will stir the instinct of courtship without evoking the idea of its natural end and object.

Smell and sex have been correlated since ancient times, but the subject of smell was long ago tabooed, chiefly on account of this correlation. This may explain why our knowledge of the subject has not progressed further, notwithstanding that much has been written about it by various classes of authors. As substantial evidence of the part played by smell in matters of sex, we are referred to the lower animals, particularly to dogs, and then taken back to the time of Aristotle as a starting point for the remainder of the story. Further than that, it is known that erectile tissues have been found in the human nose, and the correlation between this structure and the generative organs has long been a matter of universal medical knowledge.

Several writers claim that woman, in all ages, has appealed largely in courtship to the olfactory sense of man. Through all the ages there has been a definite relation between the nose and sex, although the human species has been practically unconscious of it. This subject should be thought of as beautifully expressed by Tennyson:

Through all the centuries the season of flowers—the springtime—has been celebrated in amatory song and story as the season of love and of sexual delight.

Our sense of smell in relation to certain aromatic chemicals appears to be astonishingly acute, judging from the results obtained by Fischer and Penzoldt in experiments with chlorphenol and mercaptan. Assuming that 50 cubic centimeters of the scented air in the room in which these chemicals were evaporated were sufficient for olfaction, the quantity of chlorphenol smelled in this test was only 1/4,600,000 of a milligram, and the quantity of mercaptan was only 1/460,000,000 of a milligram. This infinitesimal quantity of mercaptan, however, was estimated to contain 200,000,000,000 molecules. Of all the aromatics tested by various investigators, artificial musk has been found the most stimulating and it thus stands at the head of all olfactory stimuli. The most active mercaptan (propyl mercaptan) tested by Allison and Katz was perceived at a concentration of 0.006 milligram per liter of air, which is equal to 6/1,000,000 of a milligram per cubic centimeter. This figure is far removed from that of 1/23,000,000,000 of a milligram per cubic centimeter, furnished by Fischer and Penzoldt.

In spite of the numerous discrepancies between the results of various investigators, we must admit that olfaction is accomplished through very small, often infinitesimal, quantities of substances; and yet these quantities involve large numbers of molecules of the aromatics.

The reader may wonder how such large discrepancies come about. Briefly stated, because smell is not yet a true science; that is, we have no means of measuring odors, except by our noses, and no two noses have the same smelling ability. Further than that, the procedure of preparing and using odorous materials is not standardized. With these handicaps, it is hardly possible for the investigators to obtain similar results.

Smell and Taste do not differ Widely

Smell and taste in man and the higher animals are closely related, and often can not be separated, and in the lower animals they can scarcely be separated at all. In the higher animals the organs of both are stimulated by substances in solution. Materials to be tasted are mixed with or dissolved by saliva in the mouth, while odorous particles are dissolved by the mucous covering of the olfactory organs in the nose. Parker and Stabler say:

> We therefore definitely abandon the idea that taste and smell differ on the basis of the physical condition of the stimulus, a state of solution for taste, a gaseous or vaporous condition

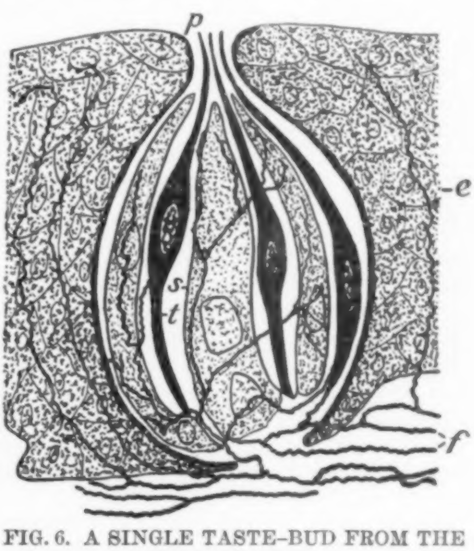

FIG. 6. A SINGLE TASTE-BUD FROM THE HUMAN TONGUE

SHOWING THE NERVE FIBERS (f) INDIRECTLY INNERVATING THE SURROUNDING EPITHELIUM (e), THE SUPPORTING CELLS (s) AND TASTE CELLS (t), WHOSE OUTER ENDS PROJECT INTO AND SOMETIMES BEYOND THE PORE (p). (FROM HERRICK, AFTER MARKEL-HENLE.)

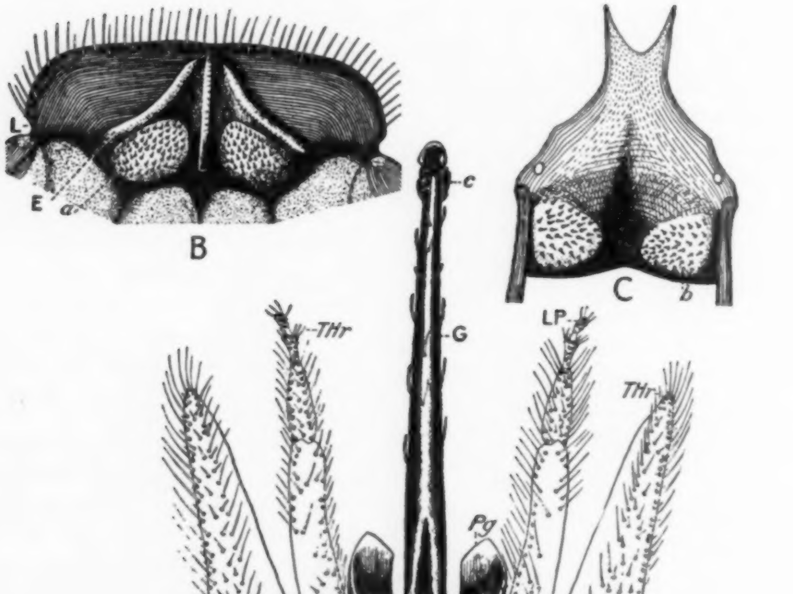

FIG. 7. THE MOUTH PARTS OF HONEY-BEE

SPREAD OUT FLAT, SHOWING LOCATION OF SO-CALLED TASTE ORGANS (*a* TO *d*), OTHER TOUCH HAIRS (*THr*) AND OLFACTORY PORES (*Por*). A, DORSAL SURFACES OF TONGUE OR GLOSSA (*G*), PARAGLOSSA (*Pg*), PALPIGERS (*P*) AND LABRUM (*L*), INNER SURFACES OF LABIAL PALPI (*LP*) AND OUTER SURFACES OF MAXILLÆ (*M*) AND MANDIBLES (*Md*); B, VENTRAL VIEW OF EPIPHARYNX (*E*) AND LABRUM (*L*), AND C, INNER SURFACE OF PHARYNGEAL PLATE. ALL THE HAIRS SHOWN ARE INNERVATED, WHILE THE EXTREMELY LARGE ONES ON THE TONGUE HAVE BEEN OMITTED.

for smell, and maintain that both senses are stimulated by solutions, though in smell, at least for air-inhabiting vertebrates, the solvent is of a very special kind. . . . In air-inhabiting vertebrates, the olfactory solvent is a slimy fluid of organic origin and not easily imitated. . . . We therefore believe that we are correct in concluding that we smell enormously attenuated solutions and taste only relatively strong ones. In this respect the two senses may be said to differ from each other more or less as ordinary scales do from a chemical balance; taste is used in determining the presence of relatively large amounts of substance, smell for only the most minute quantities.

From all that has been written on the theory of odors we may conclude that

smell depends (1) upon the volatility of the odorous substance, (2) on the solubility of the odorous particles in the watery mucus of the nose, (3) on their solubility in the fatty or lipoid ends of the olfactory cells, and (4) on the chemical reaction which takes place in these cells. A substance, says Durrans, which fails to satisfy any one or more of these factors is odorless, and it is obvious that variations in these factors will produce variations in both the intensity and quality of odors. Durrans believes that the quality of odor is determined primarily by the chemical properties of a substance, whereas the intensity is simultaneously governed by the physical properties.

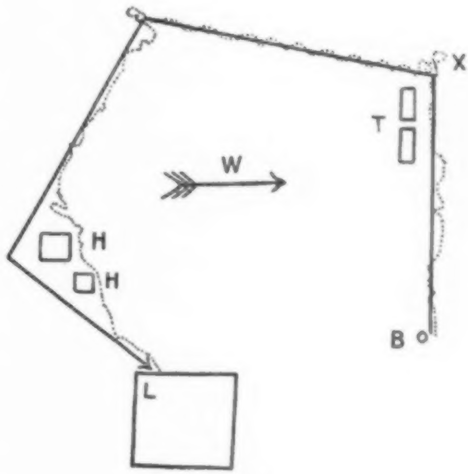

FIG. 8

ON A LEVEL SANDY PLACE IN AMSTERDAM A BOY FOLLOWED THE ROUTE INDICATED BY THE SOLID LINE. THIS ROUTE DEPARTED FROM A TREE (*B*) AND ENDED AT A LABORATORY (*L*). AT *T* THERE WERE TWO STREET CARS AND AT *H* TWO HUTS USED BY CONSTRUCTION WORKERS. UPON COMPLETION OF TRIP BY BOY, A POLICE DOG WAS LED TO THE TREE WHERE HE WAS ALLOWED TO SMELL THE BOY'S CAP, AND THEN FOLLOWED THE BOY'S TRAIL AS INDICATED BY THE DOTTED LINE. A STRONG WIND WAS BLOWING IN THE DIRECTION INDICATED BY ARROW (*W*). BETWEEN TREE AND STREET CARS THE WIND SEEMS TO HAVE SCATTERED SCENTED SAND, BECAUSE THE DOG FOLLOWED TO THE RIGHT OF THE BOY'S TRACK, WHEREAS BEHIND STREET CARS, TRAIL WAS FOLLOWED EXACTLY. WHERE THE BOY TURNED TO LEFT AT *X* THE DOG HAD SOME DIFFICULTY, AS SHOWN BY HIS WINDINGS. JUST BEFORE REACHING THE HUTS, THE DOG LOST THE TRAIL, WHICH IS TO BE EXPLAINED BY THE FACT THAT MANY PEOPLE WERE WALKING ABOUT, BUT HE SOON FOUND IT AGAIN AND CONTINUED FOLLOWING IT TO THE LABORATORY. (AFTER BUYTENDIJK.)

Much has been written, also, on the theory of taste, and nearly all the writers are agreed that taste is purely a chemical process, and not physical, as many claim for smell. Briefly stated, ions are usually the keys employed for unlocking the sensations of taste.

It is well known that flavors are smell sensations. To have a sensation of smell, an actual stream of air through the upper portion of the nose is necessary, and this is accomplished best by sniffing. That is, smell is accomplished by inspiration or breathing in through the nose, while the sensation of flavor is produced by expiration or breathing out through the nose, and the intensity of flavors is increased by smacking the lips, thus helping to force the scented air through the nose.

In regard to future research along the olfactory line, Hendrick says:

The organic chemists have outstepped the physiologists; they have discovered molecular cousinships among certain odoriferous substances . . . we are engaged in what the commercial traveler calls a different line; what we want is the philosophy of smelling.

In another respect research has been in progress for some time and there seems to be light in the offing. The entomologists are at work and they recognize this function in their study of insects.

We are sorely in need of research along the olfactory line. We are still questioning as to the nature of electricity and what it is, but good men are working over it. With the phenomena of smell we are still medieval. . . . If we maintain a simple curiosity such as animates children and great men, there will come

from laboratories one fact after another which has not been known before.

In other respects smell and taste do not differ widely. Both senses can be cultivated, fatigued and destroyed. Tastes have definite names while smells have indefinite ones. The location of their respective sense organs is definitely known in the vertebrates, but indefinitely known in the invertebrates. In structure these organs do not differ as widely as is generally believed. The olfactory organs in vertebrates are illustrated in figures 1 and 2, and in invertebrates in figures 3 and 4. Figures 5 and 6 represent taste organs in vertebrates, while figure 7 represents them in an invertebrate.

Insects can smell Equally as well as the Higher Animals

For ages the dog's nose has been regarded as the most acute smelling organ possessed by any animal, but a review of the literature shows that the "noses" of insects are close competitors and possibly second to none. The sense of smell of the horse, cow, pig and elephant, and of many other domesticated and wild animals, is remarkably developed, and perhaps would compare favorably with that of the dog.

To show how well insects can smell as compared to dogs, Fabre tells us about hunting truffles, which are a species of mushroom growing under the ground.

> The dog finds the truffles by smelling the earth quite close to the tuber; but he finds his master at great distances by following his footsteps, which he recognizes by their scent. Yet can he find the truffle at a hundred yards, or his master, in the complete absence of a trail? No. With all his fineness of scent, the dog is incapable of such feats as are realized by the moth, which is embarrassed neither by distance nor the absence of a trail.

A Dutch writer makes the remarkable

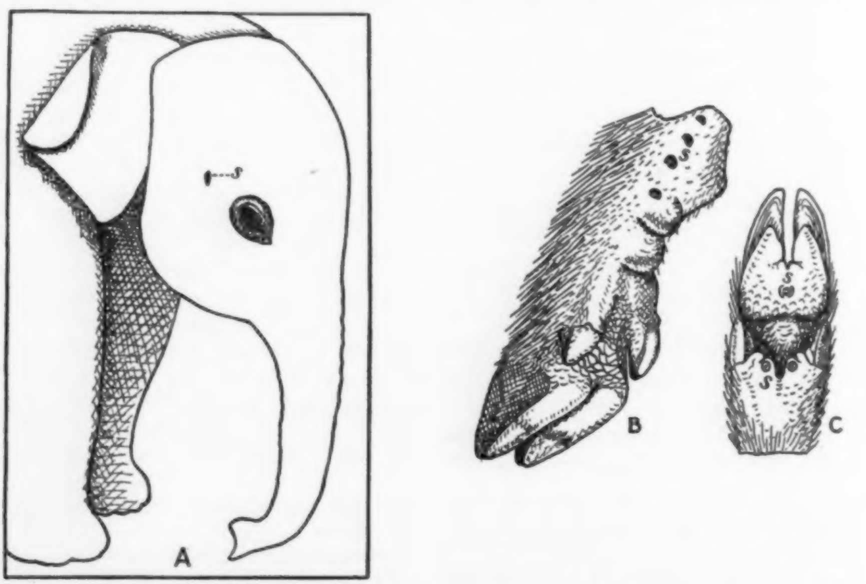

FIG. 9. THE LOCATION OF SPECIAL SCENT GLANDS IN ELEPHANT AND HOGS
A, DRAWING FROM POCOCK'S PHOTOGRAPH OF A YOUNG MALAYAN ELEPHANT, SHOWING LOCATION OF TEMPORAL SCENT GLAND (*s*) BETWEEN EYE AND EAR; B AND C, UNDERSIDE OF FEET OF HOGS, SHOWING LOCATION OF SCENT GLANDS (*s*) ON FRONT FOOT OF COMMON PIG (B) AND ON HIND FOOT OF SOUTH AFRICAN BUSH-PIG (C). (AFTER POCOCK.)

statement that more than one person has been known to be able to smell sugar in tea and salt in soup; but that Albert, a police dog, smelled common table salt and quinine in solution at a concentration of 1 to 10,000. Albert was also able to associate a pocket-book with its owner, and to distinguish pebbles which had been touched lightly with the fingers.

The dog, like people, can experience a variety of olfactory qualities; furthermore, he has the power to analyze a mixture of odors and to attend exclusively to one component of it. This is a power that we lack almost entirely. The dog, and perhaps many other animals, can analyze a complex of odors as a trained musician analyzes a chord.

Dogs can trail men and animals merely by smell, as illustrated in figure 8. Ants and termites can follow their own tracks by smell, but in these cases there are other factors to be considered, although smell is probably the most important one.

Dogs can find hidden food merely by smell; so can insects. Flower-loving insects recognize their food partly by smell, but as dogs do not care for flowers no comparison can be made on this point. Male insects find their mates partly by smell; so do dogs.

It is known that honeybees, ants, and termites communicate largely by smell; perhaps the same is true of dogs, although as to this we have no definite information. Frisch has gone so far as to call smell the "language" of honeybees, and a small book could be written on this subject alone.

Means of producing Odors for Recognition

Long ago it was stated that most animals emit odors peculiar not only to the individual, variety, race, and species, but also to the genus, family, order, and class, and that these odors are the chief means by which one animal recognizes

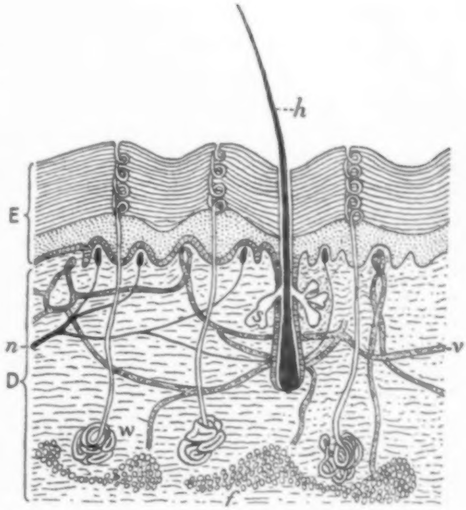

FIG. 10. SECTION OF SKIN OF MAN SHOWING EPIDERMIS (*E*); DERMIS (*D*); HAIR (*h*), ARISING FROM A HAIR FOLLICLE INTO WHICH EMPTIES SECRETION OF SEBACEOUS GLANDS (*s*); SWEAT GLANDS (*w*) AND THEIR DUCTS, WHICH PASS SPIRAL-LIKE THROUGH THE EPIDERMIS; BLOOD VESSELS (*v*); FAT CELLS (*f*), AND NERVE (*n*), WHICH INNERVATES THE SENSE PAPILLÆ. (FROM HERTWIG, AFTER WIEDERSHEIM, SLIGHTLY MODIFIED.)

other animals. Without the aid of the eyes the degenerate human nose is able to distinguish a horse from a cow, a goat from a roe, a dog from a cat, a martin from a fox, a crow from a pigeon, a parrot from a hen, a lizard from a snake, and even a carrion crow from a hooded crow.

All odors arising from the skin, hair, feathers, or scales of an animal have their sources in secretions or excretions which pass through the skin or integument by special ducts or pores, and not directly through by osmosis; in some animals, however, particularly certain insects, the existence of these pores has not yet been definitely established. The scent-producing organs, which may possibly include three types of glands—special scent glands, sweat glands and sebaceous glands—have not yet been

thoroughly and systematically studied in any order of animals, and in most cases definite and specific functions have not been assigned to the various types. Odors may also be emitted from the body at either end of the alimentary canal, but these probably play no part in recognition among animals.

Special scent glands have been found in a large number of animals, including deer, antelope, goat, sheep, chamois, musk deer, musk ox, hog, elephant, bat, shrew, beaver, muskrat, and aard-vark. In the elephant (Fig. 9, A, *s*) the large gland lies beneath the skin of the face. It enlarges in the male at the rutting season, and the secretion has a strong musky odor. Our commercial musk comes from the bag of the musk deer, and our castoreum from the scent bag of the beaver. Both of these aromatics are used extensively in perfumes and medicines.

Since the anal glands have been found in such a wide range of mammals—from the lowest (duckbill) to the highest (man)—we may assume that they are common to a large percentage of mammals. Anal glands are also present in some insects. They are most constant and best developed, as a rule, in the carnivorous animals, where, in regard to the secretion produced, they reach their climax in the polecat of Europe and in the skunk of America, but the largest ones are found in the hyena.

Other special scent glands lie in the feet, and their secondary function is probably to leave scented tracks wherever the animal steps. Those in the feet of hogs (Fig. 9, B and C, *s*) are good examples.

The skin of mammals, in particular, is characterized by richness in glands, of which there are two kinds. Of these, sweat glands (Fig. 10, *w*) are common to mammals, while sebaceous or oil glands (*s*) are common to birds and mammals. The sebaceous glands usually open around the base of hairs (*h*) in depressions called hair follicles, and not into the cavity or lumen of the hairs. On the palms of a human being sweat glands number 1,100 to the square centi-

FIG. 11. THE LOCATION OF SCENT GLANDS OF INSECTS

A, SUPERFICIAL VIEW FROM ELYTRON OF A COTTON BOLL-WEEVIL, SHOWING LARGE HAIRS (*h*) AND WIDELY SCATTERED GLAND PORES (*p*). B, CROSS-SECTION THROUGH TARSUS OR FOOT OF A BEETLE, SHOWING NERVES (*n*) RUNNING TO TOUCH HAIRS (*t*) AND GLAND CELLS (*g*) WHICH, WHEN STIMULATED, FORCE THEIR STICKY SECRETION THROUGH OPENINGS IN NUMEROUS HAIRS (*h*) ON THE "SOLES" OF THE FEET. (FROM PACKARD, AFTER DEWITZ.) C, FRONT LEG OF A MALE MOTH, SHOWING THE FAN-SHAPED GROUP OF SCENT HAIRS (*s*). (FROM SCHRÖDER, AFTER ILLIG.) D, FEMALE OF THE SILKWORM MOTH, SHOWING THE EVERSIBLE SACS (*s*) AS SCENT-PRODUCING ORGANS. (FROM SCHRÖDER, AFTER FREILING.) E, LARVA OF A SWALLOW-TAIL BUTTERFLY, SHOWING EVERSIBLE SACS OR OSMATERIUM (*s*), WHICH EMIT A DEFENSIVE ODOR. (AFTER BERLESE.)

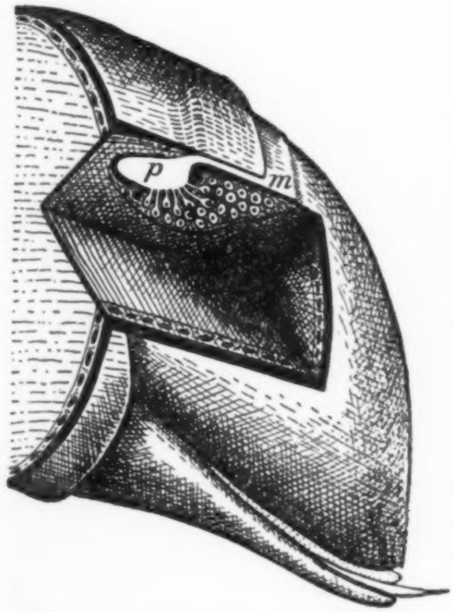

FIG. 12. THE END OF ABDOMEN OF A HONEY-BEE

DIAGRAMMATIC TRANSVERSE-LONGITUDINAL VIEW, SHOWING SCENT-PRODUCING ORGAN COMPOSED OF ARTICULAR MEMBRANE (*m*), CANAL OR POUCH (*p*), AND NUMEROUS GLAND CELLS LYING BENEATH THIS POUCH.

meter, and their total number in man is said to be about two million.

Horses and some other animals sweat freely, but it has been said that the dog, cat, rabbit, rat and mouse do not sweat at all, or, if they do, only between the toes. This statement expresses only part of the truth, because these animals do perspire on other parts of the body, although not to any perceptible extent except on their footpads.

Primarily the sweat glands constitute an automatic device for holding the body temperature at a constant degree, while their secondary function is probably recognition. The perspiration is a clear, colorless fluid with a salty taste and of different odors from different parts of the body. Sweat is 99 per cent. water and the other 1 per cent. consists of urea, ammonia, fatty substances and certain other compounds. Its neutral fats are said to come from the sebaceous glands, although the sweat glands themselves secrete other fatty substances, of which the volatile fatty acids emit the peculiar odor characteristic of sweat.

The primary function of the sebaceous glands is to lubricate the skin, hair and feathers of animals; if they have a secondary function it might be recognition. The secretion of these glands, called sebum, is an oily semifluid when fresh, but on the surface of the skin it solidifies, forming a greasy coating.

We can now understand why the odors emitted from two animals differ. We can also understand how dogs, by smell alone, even in total darkness, can distinguish their masters and the members of their households from strangers. Besides the glands already mentioned, animals have certain other glands whose secretions may also be odorous and perhaps sexually attractive; for instance, the glands connected with the genitals.

Sweat glands and sebaceous glands are present in the higher animals, but absent in insects; therefore insects, so far as we know, do not sweat. They belong to the cold-blooded animals, whose temperature most of the time corresponds more or less closely to the temperature of the air in which they live, and therefore do not need sweat glands. Nevertheless, many insects possess glands which, being widely distributed over the entire body surface, closely resemble sebaceous glands. Since these glands are not needed for lubricating purposes, they must have some other function, and that they are used for recognition seems very reasonable. Those of the cotton boll weevil (Fig. 11, A, *p*) illustrate this point.

As specialized glands under this type are the adhesive glands (Fig. 11, B) in the feet of many insects, particularly in

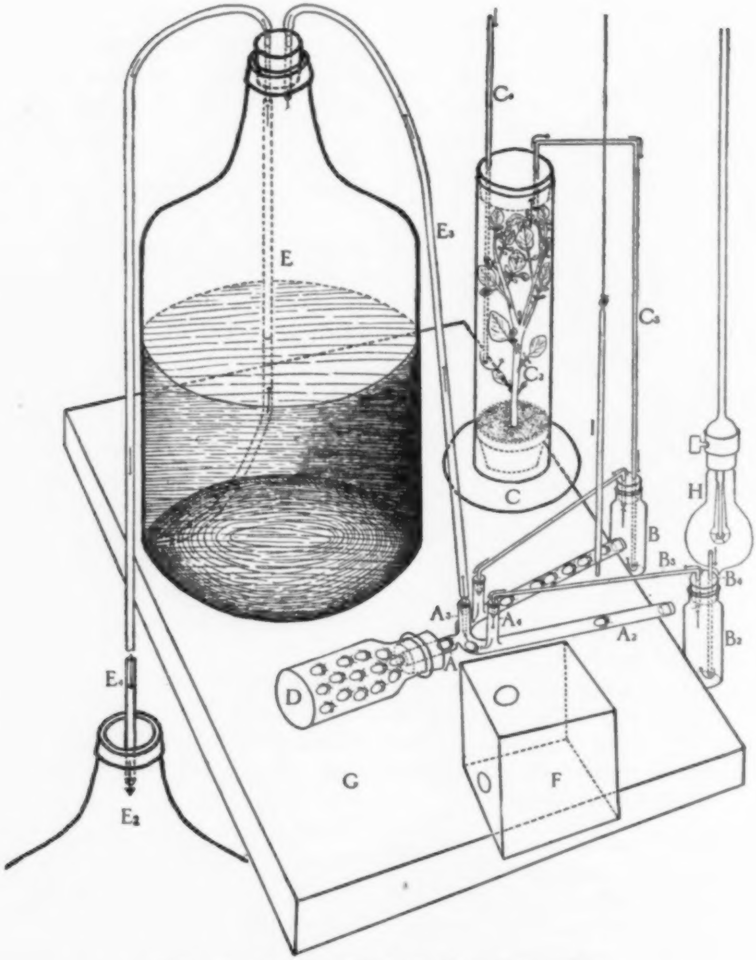

FIG. 13. AN INSECT OLFACTOMETER

SHOWING THE FOLLOWING PARTS; *A*, STEM OF Y-TUBE; A_2, FORKS OF Y-TUBE; A_3, EXIT OF Y-TUBE; A_4, ENTRANCE TUBES OF Y-TUBE; *B*, BOTTLE TO HOLD ODOROUS SUBSTANCE; B_2, BOTTLE TO HOLD CONTROL SUBSTANCE; B_3 AND B_4, EXIT AND ENTRANCE TUBES OF BOTTLES *B* AND B_2; *C*, PLANT CHAMBER; C_2, LIVING POTATO PLANT; C_3 AND C_4, EXIT AND ENTRANCE TUBES OF PLANT CHAMBER; *D*, DARK BOTTLE TO HOLD INSECTS; *E* AND E_2, FIVE-GALLON BOTTLES, THE LATTER STANDING ON THE FLOOR; E_3 AND E_4, SIPHONS, THE LATTER FOUR FEET LONG; *F*, FIVE-INCH CUBIC BOX, THROUGH WHICH Y-TUBE IS INSERTED, TO ELIMINATE SIDE LIGHTS, ETC.; *G*, THICK BOARD; *H*, ELECTRIC LIGHT; AND *I*, THERMOMETER.

all of those that can walk on perpendicular surfaces, or even upside down. Although the primary function of these glands is certainly to enable insects to walk on smooth perpendicular surfaces, a secondary use is probably that of recognition. In ants, termites, and all the other insects which follow scented trails this secondary use seems especially plausible. The adhesive glands lie in the soft pads on the under side of the feet, and are usually connected with

small hairs, called tenent hairs (*h*). These hairs are hollow, and usually open at their tip ends; and through them the sticky secretion from the glands is forced to the exterior, where under certain conditions it may be seen as fine threads. This example shows how scented trails may possibly be made by the feet of insects in much the same way as scented tracks are made by dogs, the sweat glands in the pads of the dogs' feet seeming to deposit an odorous material wherever a dog steps. Further than this, ants and termites have been observed to lay down scented trails by depositing tiny specks of material from the tip ends of their abdomens, and thereafter they follow these tracks.

Scent glands of a second type include peculiarly arranged tufts of long hairs on the legs and elsewhere on male moths (Fig. 11, C, *s*). The secretions from all these organs have been credited with purposes of allurement and are supposed to attract the opposite sex. They have been regarded as aromatic, volatile oils. Their odors usually are, to man, very pleasant indeed, and have been described as resembling many of our most pleasing scents, even including those from some of our fancy perfumes. As a rule each species of insect has its own characteristic odor.

In the case of a third type of scent glands, eversible sacs or pouches, usually lined with tiny hairs which connect with the glands, serve as special devices for storing the secretion and distributing the odors. With some species the odors from these glands serve for allurement (Fig. 11, D, *s*), and in the case of other species for defense (Fig. 11, E, *s*).

The dorsal scent gland of the honeybee (Fig. 12) belongs to a fourth type, and is one of the most highly developed of the scent glands used for recognition purposes.

The anal glands of insects, already

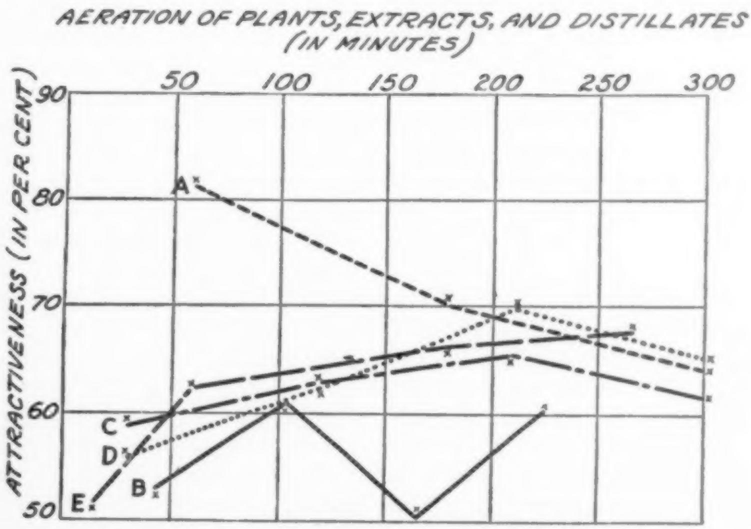

FIG. 14. THE RESPONSES OF POTATO BEETLES

TO EMANATIONS FROM THEIR LIVING HOST PLANTS, AND TO ODORS FROM WATER EXTRACTS AND STEAM DISTILLATES OF THESE PLANTS. *A*, SMALL POTATO PLANT, POTTED NINETEEN DAYS; *B*, SMALL BRANCH OF TOMATO PLANT IN WATER; *C*, EXTRACT OF POTATO FOLIAGE; *D*, EXTRACT OF JIMSONWEED; AND *E*, DISTILLATE OF POTATO FOLIAGE. THE FIRST POINT IN EACH CURVE REPRESENTS A SINGLE RESPONSE, WHILE EACH OF THE OTHERS REPRESENTS THE AVERAGE OF FOUR INDIVIDUAL RESPONSES.

mentioned, belong to a fifth type, and are supposed to serve only as defensive weapons.

Uses of Smell and Taste in Economic Entomology

The perfume industry is perhaps the most important practical application of smell, and the writer ventures to say that in economic entomology is found its second most important one. Few people realize the part which smell and taste play in helping to control insects. The information gained while using attractive baits and repellents to control insects has come about in a haphazard way, by the trial-and-error method, the most laborious and expensive procedure of all. We should no longer be compelled to use this method, but since no definite rules have been established there seems to be no other way of attacking problems dealing with the senses depending upon chemical properties. The likes and dislikes of insects in regard to attractive and repellent odors are so different from our own that a person's sensations can not be used as a guide. This paper is meant chiefly as a plea for more and better fundamental research on smell and taste, so that the information obtained may be applied more advantageously.

1. Uses of Smell in Beekeeping

Smell seems to be the chief factor on which the social life of a colony of bees is founded, and it is the sense utilized by the beekeeper in controlling them. The use of smoke has been found the most available means of controlling bees, but it might be argued that smoke is an irritant and does not necessarily control bees by affecting their smelling organs. This question is debatable, although bees can detect smaller quantities of smoke than can a person, and a small amount of it does not irritate us.

Other facts relating to smell in beekeeping are as follows: (1) A new hive odor is formed in uniting colonies. (2) The foreign hive odor is eliminated when queens are introduced. (3) Bee odors help in catching swarms. (4) The absence or presence of the queen odor helps us to tell whether or not a colony is queenless, and aids us in locating lost queens.

2. Attractive Baits help to control Many Insects

It is questionable whether smell is the only sense used by insects to distinguish attractive baits; taste should therefore be included, although the writer believes that insects lack a true sense of taste. Two kinds of odorous materials are used in controlling insects, attrahents, usually called "attractants," and repellents.

The more extensively science is applied to better living, the more man thinks of ridding himself of his numerous pests. For ages grasshopper or locust plagues were tolerated as if an efficient control were impossible, and, in fact, there would still be no preventive had not economic entomologists prepared a food which proved more attractive to grasshoppers than are their natural food plants.

Attractive poisoned baits for grasshoppers were first tried in 1885 in California. They consisted of bran, arsenic, sugar and water. Cheap molasses was later substituted for the sugar, and even to-day molasses is still generally used, although some writers doubt whether it really adds to the attractiveness of the bait. By 1892 grasshopper baits, consisting of bran, Paris green, molasses and water, were found successful. After entomologists had prepared a food which grasshoppers liked better than their natural one, the next problem was to improve it in every way possible, particularly in regard to its inexpensiveness

and attractiveness. Finely chopped oranges or lemons were added to make the bait more attractive. Many other substances have since been tried as attractants, but the next important step was the substitution of amyl acetate or banana oil for the very much more expensive oranges or lemons in the bait. Now let us cite one example of recent grasshopper campaigns to show the immense quantities of poisoned bait used and the millions of dollars saved by its application.

In 1921 war was declared against grasshoppers in western Canada, and the campaign was organized on a semi-military basis. In Saskatchewan the supplies furnished to the municipality amounted to 2,720 tons of bran, 225 tons of sawdust, 112,636 gallons of molasses, 2,805 cases of lemons, 166 tons of arsenic, 34 tons of Paris green, and one barrel of amyl acetate. The campaign in this province alone is estimated to have saved the crops on 1,400,000 acres.

Attractive poisoned-bran baits are also used as control measures against army-worms, cutworms, crickets, and earwigs, thus saving the farmers and others millions of dollars.

Everyone knows that ants are very fond of sweet foods. At first thought, therefore, it would seem an easy matter to induce ants to eat poisoned foods; not so, however, for they are too "smart" to be easily fooled in such a manner. In fact, man with all his intelligence had to experiment a long time before he succeeded in preparing a poisoned food which they relished and would carry to their young in the nest. Perhaps Solomon with all his wisdom could not have succeeded in this difficult task.

Ants have always been found very difficult to control even when all known measures have been employed against them. Poisoned baits for ants were formerly not considered successful and were seldom recommended. The first poisoned baits tried against ants were very simple, consisting of a sweet substance, sugar sirup or honey, to which was added poison such as arsenic or Paris green. From time to time other substances were added to the sweet liquids, but very little improvement resulted in this way. The greatest improvement was the discovery of the proper proportion of the ingredients, and the best method of combining them. But this discovery was not made by our economic entomologists until about 1909, when the presence and spread in our southern states of the Argentine ant, the worst ant pest the world has ever known, demanded a far better material and method for ant eradication than any that had been devised. After many trials and failures, or partial failures, a satisfactory bait was finally prepared which is now generally recommended as a remedy against all noxious ants. It contains honey, sugar, water, sodium arsenite, tartaric acid and benzoate of soda. Great care has to be exercised in preparing this bait, and particular attention has to be paid to the cleanliness of the vessels used, for if the bait accidentally becomes flavored with any undesirable substance the ants will "leave it severely alone."

In 1922 the Argentine ant was discovered in Mississippi, and since then successful campaigns have been waged against it by the use of thousands of cans of the bait described above. The State reports for 1926 declared that the ant campaigns had been entirely successful and that complete eradication in Mississippi seemed near at hand; they remarked that the people knew that if this ant was not eradicated, every property and every house, barn, store, and other building would become infested, thus causing an annual loss of millions of dollars not only to themselves, but

later to their children and grandchildren. War against this ant by the poisoned bait method is also being successfully waged in our citrus orchards, especially those of California, and in foreign countries.

The struggle against the olive fly, the worst enemy of the olive tree, has been a long and hard contest that has seriously taxed the ingenuity of man, and apparently no progress was made until some one discovered that the olive fly had a "sweet tooth," and could be led to its doom by attraction to poisoned sweet foods. How this was finally accomplished is a long story, extending over a quarter century, and can not be related here. It appears, however, that all the countries troubled with this pest are now generally using the method, which consists of spraying with a poisoned sweet, and that they spray only a part of each olive tree; in fact, only enough of it to attract the olive fly. This reduces the danger to beneficial insects, which are more abundantly attracted when the entire tree is sprayed. A syndicate for controlling the olive fly has been organized in Italy and a standard formula—90 gallons of water, 100 pounds of molasses, and 2.5 or 3 pounds of sodium arsenite adopted for the spray. Thus the seemingly trivial discovery that olive flies are attracted by sweet substances has led to practical methods whereby the olive industry in many parts of the world, involving millions of dollars, has been saved.

Other fruit flies, including the Mediterranean fruit fly and the melon fly, are partly controlled by attractive baits. The house fly and its near relatives are attracted by many substances used as baits, but we are not yet certain what constituent or constituents in their food really do the attracting. More research is badly needed here.

Many efforts have been made to discover successful attractants for noxious moths and beetles, but so far few practical methods have been devised, although work along this line is now being carried on more seriously than ever before, and the results already obtained are very promising. This work has dealt chiefly with the codling moth, which causes wormy apples, the oriental peach moth, and the Japanese beetle. The most promising and striking example of how a definite chemical constituent can allure myriads of insects to their destruction is the use of baits scented with geraniol to attract Japanese beetles, as recently demonstrated by Richmond, at Riverton, N. J. For twenty years or more much has been done toward developing a remedy for the strawberry root weevil, but not until recently has a satisfactory control measure been discovered. An attractive poisonous bait has at last been developed by Forsell. It is claimed that the discovery and perfection of this bait marks an important horticultural step in the fruit industry of the state of Washington, because this weevil had become so serious in many places that the strawberry-growing industry seemed doomed.

3. Repellents help to control Many Insects

As already stated, attractants lure insects to traps or to poisoned baits where they may be killed by sprays or otherwise, or where they die after eating the poisoned food. Most repellents, on the other hand, are usually effective for short periods only and have to be frequently renewed. For a time they will keep harmful insects a short distance from our bodies and those of our animal friends or from our cultivated plants. A few repellents, nevertheless, may be effective under certain conditions for long periods. As examples, those employed to repel insects from stored

clothing and museum collections of insects and other animals may be cited.

Smoke has been referred to as a repellent to control honeybees, and it is also an effective one against mosquitoes and biting-flies.

Many substances used as repellents emit poisonous exhalations. It is questionable whether in these cases it is primarily through the action of the olfactory sense that the insects are driven away. In other words, we do not know whether the repellent effect is caused by the stimulation of the smelling organs by these exhalations or whether the insects are injured by the passage of the exhalations into the breathing pores. Poisonous repellents include coal tar and petroleum and many of their derivatives, such as naphthalene, carbolic acid, and kerosene. In other cases the olfactory sense is certainly the primary factor to be considered.

People long ago began to search drugstores for mosquito repellents and among the first ones tried were camphor and certain essential oils. By 1900 a large list of aromatics were being used as mosquito repellents, oil of citronella being the most promising. There are now numerous mosquito "chasers" on the market. Most of them are effective, although rather expensive, and perhaps in most cases not so efficient as those recommended by entomologists and medical men. They are usually composed of one or more essential oils combined with some heavy oil or grease and are to be applied as a lotion, spray, or ointment, depending on their consistency.

How do these substances afford protection against mosquito bites? One writer claims that mosquitoes are guided to a person in the dark by the odors emitted from the skin, and that all that is necessary is to disguise the smell of the skin. He concludes that the so-called mosquito repellents are not really repugnant to these insects but are effective merely because they change or disguise the attractive odors from the human skin. A second writer believes that these substances repel directly by emitting odors or vapors which are disagreeable or harmful to mosquitoes.

Before 1889 there were a few fly repellents on the market, but during the first decade of the twentieth century the proprietary preparations of this character had greatly increased in number. The two most important types of repellents introduced at this time were the sprays for the protection of dairy cows and the mixtures designed to prevent certain kinds of flies from laying their eggs in the wounds of livestock.

In the effort to prevent flies from laying eggs in wounds, where their larvae or maggots produce a disease called myiasis, much experimental work has been done. In the Southwest screwworm flies cause an annual loss of about $4,000,000 to the livestock industry. Since 1915 Bishopp and his co-workers in Texas have taken the lead in this research. One of the control measures recommended is the use of repellents, a very effective one for practical use being a mixture of one part furfural and 4 parts of pine-tar oil.

Repellents are included among the control measures for blowflies, tsetse flies, botflies, certain buffalo gnats or black flies, certain midgets causing sandfly fever, and a few beetles, moths, and other insects. In most cases, however, repellents, for various reasons, are not reliable remedies.

4. Do Plants attract Insects by Emanations?

It is well known that flower-loving insects are attracted to flowers by two senses—sight and smell; and the controversy as to which is the sense that

mainly guides these insects in their quests has apparently been settled by the decision that sight is the more important. In spite of this it can not be stated positively that the whole truth regarding this is yet known, because the experimenters did not entirely control or eliminate the other senses while trying to prove the function of the sense in question. Since only a small percentage of insects are flower-loving, the results pertaining to them have only an indirect bearing on all the other insects which search for host plants. Certain members of this larger group of insects have recently been studied by the writer while making a fundamental investigation of plant emanations, attractants, and repellents. In order to be certain that no other sense aided the olfactory responses, a special apparatus was developed which practically eliminated or controlled all the stimuli except the olfactory ones. Economic entomologists have become more and more interested in this general subject and a study of the fundamentals underlying it would be of interest to all students of the interrelationships of plants and insects.

Briefly, the apparatus, called an insect olfactometer, consists of a specially constructed glass Y-tube (Fig. 13, *A*, A_2, A_3, A_4) through which insects pass from a dark chamber (*D*), being attracted by a light (*H*) suspended near the free ends of the forks of this tube. The dark chamber is attached to the base of the Y-tube, while a suction apparatus (*E*, E_2, E_3, E_4) to draw the odors through the forks is attached at the point where the base and forks unite. The principle involved is to attract the insects equally toward the entrances of the forks by the light stimulus, but when they are ready to enter these forks they are influenced unequally by the odors drawn through the forks, one fork serving as an attractive or repellent side and the other fork as the control side. The whole apparatus is so constructed and manipulated that the interfering factors are practically controlled, leaving only the olfactory responses to be recorded.

When testing the emanations of plants, the apparatus with the plant chamber (*C*) attached was assembled as shown in Figure 13, and the odorous air from the plant on the left and the non-odorous air from the control side on the right were drawn through the apparatus as indicated by the arrows. Emanations drawn through the apparatus from living potato plants could not be detected by the writer, but in every one of the 24 experiments conducted, each consisting of four individual tests, the beetles gave attractive responses, the highest individual test giving 81.2 per cent. (Fig. 14, *A*) and the highest average for four individual tests being 76.7 per cent.

Since potato beetles, when potato plants are scarce or entirely wanting, feed on the horsenettle, jimsonwood, tomato, henbane, and a few other related plants, all belonging to the potato family, the preceding experiments were repeated with some of these plants. The results obtained (Fig. 14, *B*) indicated that the beetles liked the emanations from these plants very little in comparison to those from potato plants, although in or near potato patches it is common to see these insects on one of them, the horsenettle.

When testing the water extracts and steam distillates of these host plants, the apparatus was used with the plant chamber disconnected, the extract or distillate being put in one bottle (Fig. 13, *B*) and distilled water in the control bottle (B_2). It was thus shown by a long series of experiments that potato beetles can be induced to respond to their food odors by subjecting them to the odors from these extracts (Fig. 14,

C and *D*) and distillates. These results and those pertaining to the emanations give indisputable proof for the first time that plants (not flowers) attract insects by emitting odors.

After aerating the steam distillates of potato foliage (Fig. 14, *E*), potato tubers, horsenettle, henbane, and tomato plants for some time, odors from all of these distillates became attractive to potato beetles, and the writer could detect a common odor among them. This odor closely resembled that from boiling potatoes or from the juice of freshly cut potatoes, and might be called a potato odor. Since all these plants belong to the potato family, it would be interesting to know whether they possess a particular constituent or constituents emitting a common odor, as indicated by the responses of the beetles and by the writer's nose. If so, it is suggested that the chemist tell us what it is, so that we may use it in poisoned baits or in traps, thereby perhaps reducing the cost of controlling potato beetles, which must now be done by dusting and spraying the potato plants.

THE CHAINS OF PROMETHEUS

By Dr. BENJAMIN C. GRUENBERG
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WHILE every increase of knowledge means an increase of power, it means also an increase of sorrow. This is not to say that ignorance is bliss, or that wisdom is folly. It is only to recognize that knowledge does inhibit action, does dampen enthusiasm, does increase the burden of care. It is not necessary to defend knowledge, or its modern equivalent, science. But it is necessary for us to understand something of its nature and its limitations, of its dangers and its implications, as well as some of its concrete products and applications.

PROMETHEUS, REVOLUTIONIST

When Prometheus stole the flame from heaven he not only embarrassed the gods. He conferred upon man the most precious of gifts and set the pattern for all subsequent revolutions. This pattern consists essentially of violating established custom by means of a radical innovation that disturbs the complacency and self-esteem of the population and arouses the resentment of the authorities. In the course of time the novelty of any novelty wears off; and then the revolutionary device is no longer a novelty but part of the accepted order of nature, an integral unit in the eternal verities, in fact.

Consider fire. At one time this was an innovation, and a violation of the normal and divine order of the universe. For thousands of years, then, to play with fire meant not merely to incur the known risks of a partially controlled force, like hunting wild beasts at the risk of getting killed. It meant much more than that, and something quite different. It meant to trifle with magic, to pry into holy mysteries, to challenge the gods; it meant to tempt providence, to defy heaven itself. Nevertheless, the merits of fire gradually insinuated themselves into the consciousness of man. Throughout the ages countless eulogies have been pronounced in praise of fire, its virtues have been widely extolled, and it was earnestly defended against its enemies.

NOVELTY STALES

To-day, this strange force has become assimilated into our daily lives. It must now be a long time since any one has rushed to its defense or composed a poem in its vindication, or since, on the other hand, any one has seriously attempted to discredit fire as a treacherous friend, as an ever-present source of danger, and its use as contrary to the obvious purposes of nature and all the gods. We no longer fear that a wide distribution of strike-anywhere matches will increase the temptation to commit arson. Although the destruction due to fire amounts to hundreds of lives and millions of dollars in property every year, even children to-day accept fire as part of nature and of the orderly routine of life. We do still retain a few ceremonials that point to the primitive attitudes, but most of us do not take them very seriously even as ritual. What was once a solemn business calculated to keep us in communication with the gods through our high priests has degenerated into child's play or empty pageantry. We have become so thoroughly habituated and indifferent to the presence of fire that friends and foes alike have all but forgotten Prometheus.

WHAT PRICE KNOWLEDGE

The fire of Prometheus comes then to be considered a matter of course, and a

valuable gift from on high. If now we accept the benefits of this wonderful process of oxidation, we must recognize also that, like every other advantage, this gift has carried with it serious dangers, whether we consider the material benefits of fire in the concrete, or the spiritual benefits that are symbolized by the torch. It is true that we do not have to burn our houses in order to roast our pigs, but we can not roast our pigs without losing many houses, and an occasional human life, in the process of acquiring skill and safety in the use of fire.

There are two points here for our consideration. On the one hand there are the unquestionable risks and dangers inherent in every form of force. The ancients had no practicable steam engines, but neither had they boiler explosions. You discover that mushrooms are good to eat, and that is clear gain. You discover only later that there are mushrooms and mushrooms; then there is wailing and sackcloth. That is to say, there is the danger of knowing, but knowing too little. On the other hand, there are the capacities for understanding and control and utilization inherent in the spirit of man. We can learn to distinguish one mushroom from another, we can learn to use steam without boiler explosions, we can learn to use horse serum without anaphylaxis. That is to say, there is the hope of clear vision and deeper insight. Whether in any given case mastery or disaster will be realized, or how much of each, constitutes the whole issue between fear and superstition and inertia and reaction on the one side, and science, vision, enterprise and progress on the other. And all this applies to many later gifts no less than to fire.

Innovations must Destroy

Every new instrument whereby man has increased his control of natural forces has carried with it the possibility of destroying both human life and the things we value. The revolutionary thought or device often does violence to the things of the spirit as well as to our material possessions. We may be tempted to disparage the hostility to science by saying that the spiritual treasures which new ideas threaten are merely prejudices, merely superstitions; they are nevertheless precious to their owners, and essentially of the same stuff as the analogous beliefs and theories of our more enlightened colleagues. We may be tempted to sneer at the bungling crafts and the obsolete instruments of those whom new inventions displace; but the old crafts and the old tools are of vital significance to those for whom they have meant a way of living as well as a means of livelihood. Every innovation must meet the resistance and active opposition of a certain portion of the population.

The Comfort of the Customary

To all people the familiar way of life, the customary, appears as the natural. It is natural, many people are certain, for traffic to pass to the right. In other countries, where the general level of intelligence is presumably as high as it is in this country, it appears to be natural to turn to the left. An attempt to obtain uniform practice, for reasons which seem to be good and sufficient to those who have studied the problem, is sure to be met with resistance. Now it is strictly in accord with human nature to acquire habits, as we may call them for short; but it is also in accord with human nature to resist every pressure to change habits. If it be proposed to have all turn to the right, the English and Austrians and Italians will present good reasons why they should not change—their practice goes back to times when the memory of man knows not to the contrary. If it be proposed that we all turn to the left, the Americans and Germans and French will offer equally good arguments why they should not yield; certainly

they could not readily see why the obviously desirable uniformity should be obtained at *their* expense. All of us, however, will admit that it would be highly desirable for other people to adopt our customs.

Common Sense

The customary and familiar are not only natural, but they accord with common sense. If we find peoples with different customs, it is evidence that they are queer. Yet, if they eat the hearts of their enemies with the absurd idea of thereby gaining courage, we eat celery, or drink celery compounds, to strengthen our nerves, or go to fish for brain food. If strange people curiously slaughter their animals with rituals and magic words, some of us are strict vegetarians for equally solemn reasons, or plant our acres according to the phases of the moon. With certain peculiar sects, respect is indicated by covering the hair; yet we consider it common sense for the male of the species to manifest respect for persons, monuments, churches or symbols by removing the head-gear. In any case, however, it seems to be common sense to do as we have always done.

For millions of people who have been brought up on chlorinated water, the treatment of water with chlorine for the purpose of destroying bacterial life is a matter of course, common sense. Of these same people, however, a considerable proportion will revolt at the suggestion of treating their water supply with iodin. They don't want their water "doped." The editor of a Seattle paper writes eloquently, "If some people want that stuff in their water, let 'em have it; but don't force it on the rest of us." In Minneapolis and in other cities, committees of cultured ladies and gentlemen protested that they wanted their water and their table salt just as nature intended it to be. There may be involved here a bit of the notoriously dangerous little knowledge: "that stuff" means to some people a dark purple or brownish substance, with a not very pleasant odor, whereas the "iodin" which the doctors propose to put into the water supply is a rather handsome crystal of potassium iodid that not one person in a hundred would distinguish from common salt, and that no person at all could discover through the senses after it was placed in the water. There may be good reasons for treating a community's water supply with iodin, and there may be good reasons against the proposal; but these reasons do not lie in common sense, they lie in a variety of technical considerations for which one needs special information, and perhaps special training also. At any rate, the basis for opposition in most cases is to be found in the violation of custom and prejudice.

In Praise of Inertia

Any demand for a change in customs or usage is resisted by us not on the ground that we do not like to change our habits, but on the ground that the new proposals are in violation of common sense. That is to say, we are inert because we are inert, and we rationalize our inertia because our intellectual vanity requires justification of our conduct in terms of reason or sense. In many cases, also, the demands and proposals of innovators are offensive because they presuppose knowledge which is not shared by all, that is, knowledge which is not common; and we can not help resenting the insolence of those who set themselves up as superior.

Natural Rights

Closely related to the rationalization of our accustomed behavior and values as being natural and in accord with common sense is the sensitiveness of the personality to any invasion from without. We insist upon our natural rights; we are all strong for personal liberty. Without searching too closely into the nature and sources of these rights, and

without determining critically the sanctions of personal liberty, we are satisfied that our rights do somehow coincide with what is natural and proper. But personal liberty turns out very often to mean no more than our insistence upon our right to continue to do as we have always done. The dairyman who has established a life's routine in terms of producing and distributing milk in a certain way will resent as an invasion of his personal liberty and his natural rights the attempt of a health board to regulate the conditions under which he may continue his business efforts. The fact that his business is affected will complicate matters because he has the natural right to make a living, and as much more as he can, by the method which he has always followed, and which has always been tolerated as legitimate. Whatever reasons may be given by the health authorities for tuberculin testing, for pasteurization, for sterilization of equipment, for minimum fat-content, may mean something worthy to the health officer, or even to the ultimate consumer: to the dairyman these things all mean irritating interference with the natural and common-sense procedure that has been recognized as legitimate, even praiseworthy, from time immemorial, and infringements upon his personal liberty.

And Personal Liberty

Most of us become so thoroughly indoctrinated with reliance upon the familiar as absolute that we seem to be constitutionally incapable of entertaining new ways of thinking, or of tolerating strange ways of interpreting the facts of life. Under the circumstances we must always resist new ideas and we must resist also the methods by which new truths are dug out of the old earth. For those of us who can not understand the new concepts, who can not adapt ourselves to the demands of the new gods, opposition is natural enough. In a large proportion of cases the opposition is one of fear. After all, there is always danger in the unknown; and in the presence of danger caution is wisdom. After all, regardless of its merits and possible uses, fire *does* destroy houses and even human lives. More and more, however, hostility to the advancement of science and to the applications of science appeals not so much to fear as to the universal desire for freedom. And this, as I have tried to intimate, is in effect the right to do what one is accustomed to do, whether it is getting drunk or expectorating promiscuously.

A writer in Massachusetts reporting on the achievements and failures of the last legislature says among other things: "It is still the inalienable right of all typhoid carriers to infect others if they happen to prefer food handling to other methods of livelihood." There is reason to believe that this was writ sarcastic, and sarcasm always suggests the superiority complex. Yet in the minds of those who are threatened with the type of legislation discussed this is a serious matter that affects the very foundations of happy living—for the individual. Opposition to such legislation can be justified in terms of common sense—that is, the traditional and prevailing assumptions. We must be permitted to do as we have always done unless reasons to the contrary are overwhelming. But reasons to the contrary never are overwhelming—unless we know all that is involved, unless, that is, we come into possession of the new knowledge.

Knowledge a Hindrance

In the absence of knowledge impulses find free play without inhibition. It is this that constitutes the happiness of the infant; it is this that makes the idiot cheerful. It is the inhibitions of painful experiences, the inhibitions of conflicting impulses, that make knowledge and thought possible. And with every new addition to our knowledge and thought

there appear new inhibitions, new obstacles to doing what we feel like doing. We may be throwing what we no longer need wherever we find it convenient to do so; the discovery that our neighbors can make their objections effective, or the discovery that refuse may become a source of injury or disease, must give us pause.

Science comes to be wicked because it threatens our liberties. To the degree that scientists are permitted to influence our customs and our laws, to that degree are we beset with regulations and restrictions and interferences with our natural—that is to say, our habitual—modes of life, with our happiness. It is for these reasons that science has become anathema, for those who do not understand its methods and its aims.

Resignation to Necessity

Most of us have learned to accept certain revolutionary innovations without violent protest. We agree to build our houses according to the building code. We agree to have our wiring done by licensed electricians. We have even moved away from our farms before the ploughing was finished because we were assured that flooding our land was necessary to save a city fifty miles away. It has become feasible, in most parts of the country, to get the public to cooperate in preventing the pollution of streams and bathing beaches. Several millions of our population have voluntarily assumed the restraints upon personal freedom implied in a knowledge of the hookworm's life-history. We are by no means unanimous regarding either the reliable knowledge or the standard practice in the matter of alcoholic beverages: there are in the situation elements of religious tradition and political dogma as well as of personal indulgence and puritanical bigotry. On the whole, however, civilized people the world over are accepting the restrictions that are implied in the mechanisms of the so-called scientific age with more and more resignation. They are voluntarily renouncing certain liberties in return for certain concrete benefits that the electricity and machinery offer them.

In Praise of Ignorance

In making application of the younger sciences, those that have emerged from a study of organic processes, the public is not so well prepared to renounce and to cooperate. People who pay rent can see why the building of tenements and the installation of plumbing should be regulated by law; but they can not all see why established industries should be regulated by law as to hours of work, or as to output of smoke and noise, or as to sex discrimination. Pedestrians can see why the state should restrict car driving or the erection of bridges to those who can demonstrate some degree of skill and proficiency in these arts; but they can not all see why the practice of the healing arts should be thus restricted. Healing is for too large a part of the population still akin to the miracles and magic of religious practice. "Many believe in divine healing," says a widely known preacher, "and therefore are conscientiously opposed to any man-made remedies in any form. Under our established principle of religious freedom, such citizens ought to be left free to follow their own conscience in such vital matters as vaccination." Those who drive cars can see why jay-walking should be prohibited but they can not all see the sense of the many personal and impertinent questions that the marriage clerk is likely to ask if they cross the state line.

Knowledge and Opinion

In every case we are ready to submit to the prohibitions and compulsions of the mechanisms which we understand or control; in every case we are disposed to revolt against the constraints and checks of the instrument that we do not control

or understand. The elaborate precautions taken to assure aseptic conditions in an operating room involve expense and delay, but they are burdens cheerfully accepted by those who know upon what they rest; to others they may be empty rituals. The silver nitrate which is in many states used in the compulsory medication of the new-born is another such interference with personal liberty and private opinion, it is another burden of expense; but it is accepted as a matter of common sense, or resented as a violation of natural rights, according to the kind and degree of enlightenment one has in such matters.

Abuse of Knowledge

Attempts of legislatures, and of others placed in authority, to impose restrictions of various kinds are likely enough in many cases to be arbitrary and to lead to abuse of power. It is possible to rationalize arbitrary acts and those that do indeed constitute abuses just as it is possible to rationalize our fears of the new and our dislike of authority. The fact that knowledge is power places those who know at an advantage; and naturally those of us who do not know become suspicious and resentful. It can not be claimed that either professional scientists, or those in a position to make use of scientific discoveries, have always considered primarily the welfare of their fellow citizens. It is possible to misuse science, just as it is possible to misuse any force; but that does not make science wicked, or its use a violation of nature's purpose.

Knowledge brings Freedom

Those of us who are engaged in education, and particularly in the teaching of science, are in danger of becoming rather complacent. We are apt to rely too easily upon the widely accepted doctrine that knowledge is power, and *ipso facto* of benefit to mankind. We take for granted the adage that truth will make us free. This assumption is seldom challenged and very seldom do we ask ourselves just how it is that truth brings freedom, or what kind of liberty it is that truth insures. Neither the votaries of truth, or of its modern substitute, "science," nor the obscurantists and intuitionists are entirely wrong—or entirely right. Man's ability to discriminate among phenomena that are superficially alike, his ability to doubt and to question, his ability to look two or three or a million times to make sure, his ability to experiment, all those things about man that differentiate him from other anthropoids and from all other living things, have made possible an accumulation of reliable facts, and an elaboration of workable theories, which compel a form of living that is anything but "natural." The increase in knowledge has increased productivity of economic effort and so has increased leisure. It has lengthened life, and so has made available increased leisure during those age periods in which men and women are most concerned with the value of time and most skilled in the use of time. It has made possible a rate of transportation and of communication which is beyond any but the wildest fantasies of earlier times. In these and related ways science has increased our freedom by giving us more power, more time and more scope for fulfilling the heart's desire.

And New Restrictions

With each addition to man's equipment there have come, however, a host of restrictions which to the uninitiated seem arbitrary and disproportionate to the alleged benefits. Thousands of people in all parts of the country will clamor on the slightest provocation for raw milk, when science recommends pasteurization; but neither the producer of milk nor the consumer is any longer free to follow tradition or common sense. "Do Not Spit" is still an injunction

that for many people involves merely a matter of taste, about which we are advised not to argue.

Improved and cheapened means of transportation, with increased leisure, tempt us to travel abroad; science, that is, would free us from certain types of provincialism. We find, however, that in addition to the political restraints of passports and visas, which are the very embodiment of ignorance and supersition, we have to submit also to quarantine restrictions and vaccination requirements, and even to the discomforts, not to say humiliation, of medical examinations—which are supposed to be the very embodiments of light and learning.

The more we learn about the obscure forces and microscopic organisms and invisible processes, the less freedom have we to do as our impulses direct or as our traditions demand. From the disposal of bodily or domestic refuse to the manufacture and sale of various commodities, more and more of our activities come to be regulated and restricted by considerations entirely foreign to the common sense of our fathers and to our convenience and aspirations. When Prometheus was finally unbound it is certain that his chains were bequeathed to those who would use the stolen fires. Apparently we can not have one without the other.

Educational Need

Scientific knowledge has accumulated faster than the general population can assimilate it. Moreover, new knowledge is always the discovery of specialists, so that at every point all but a very few must remain in outer darkness. We must take a large part of the liberating truth on faith. It is not enough, however, to tell the world that iodin is of value in certain cases as a preventive of simple goiter; the world ought to know how that was found out. It is not enough to teach that toxin-antitoxin does do whatever it is supposed to do: those who, for any reason, oppose its use can speak even louder. It is necessary to take the public into our confidence and to tell it how we have come to know. And increasingly, the diffusion of new knowledge devolves upon agencies outside the schools.

From the point of view of acquainting every new generation with the accomplishments of the past, both as addition to knowledge and as improved skill in the further conquest of the universe, it would seem insufficient to emphasize merely the concrete achievements that science has made possible and that every simple mind can value to a degree. It would seem important further to carry into our teaching an appreciation of the cost of science. And this cost must be made clear not merely in terms of the devotion—and frequently the sacrifice—of those who dedicate themselves to research, but also in terms of the inevitable restraints that every new technique imposes.

Masses in the future will have to learn what only a few have learned in the past, namely, that the attainment of truth is a continuous process and never an accomplished fact; that with every gain there comes a new set of inhibitions. It is no paradox to say that the liberations made possible by the truths which we know as science are made possible by self-imposed prohibitions and compulsions. The most difficult conditions which advancing science imposes upon us is that of starting each day prepared to scrap some of the cherished beliefs of the past. Advancement of science means not only deriving new power and new freedom out of new insight; it means also the acceptance of new disciplines, and new obligations, new restraints upon our impulses and prejudgments.

We can not have the torch without the chains.

THE HUMANIZING INFLUENCE OF PESTILENCE[1]

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"TOWARDS evening when, according to Jewish belief, the gates of Heaven are shut, and no prayer can then obtain admittance, I heard a voice, with a ripple of tears that were never wept by human eyes. It was the death rattle of a soul sinking down dead tired at Heaven's gates." Few passages can equal and none excel these words of Heine to depict the desolation of the human heart of which plague has ever been the supreme affliction.

"And Moses said unto Aaron take a censor and go *quickly* unto the congregation and make an atonement for them: the plague is begun. And Aaron took as Moses commanded, and *ran*, and stood between the dead and the living." So there hangs on my tongue's end the greatest romance of medicine in the combat and overthrow of pestilence. The most human document relating thereto was written in 1485 by Bishop Bengst Knutsson, of Västerås in Sweden, a versatile man, physician to boot, trained at Montpellier. It is the first book printed in London with a title page, for printing was a very new method of reaching the people in those days. The first press had been set up in England less than a decade when our good bishop brought out his work. And his opening salutation in its vigor and benevolence sounds like the fanfare of the heralds of good tidings. "At the reverence and worship of the blessed Trinity and of the glorious virgin Saint Mary and the conservation of the common weal of all christian people, as well for them that are whole as for remedy of them that are sick." I should like to have met this physician of Montpellier, who in his struggling days wandered from house to house, as he himself tells us, penniless like those poor patients of his who could not escape, with loving kindness in his heart, the inspiring confidence of courage in his voice and a sprig of sweet smelling herbs in his hand. He was indeed the type of physician who plucks the jewel from the head of adversity and extracts his staunchest hope from the tragedy of disease.

They were great days these, the later Middle Ages. It was already three hundred years since Christendom awoke out of its lethargy. The stonework of Western Europe which rose fresh and white after the stimulus of the Crusades, with its pointed Gothic arches, was now weathered and old. The University of Paris and the Schools of Oxford dated back almost as far. Saint Bartholomew's hospital was three centuries old already. It was a hundred years since the Peasant's Rebellion in England had changed the face of society and the suppression of the Jacquerie in France had planted the seeds which burst into life much later in the French Revolution. It was a period of ease and the zenith of philosophy. Mantegna was engraving on copper. Donatello was reproducing in bronze "the anatomy of the miser's

[1] The author has made every effort to secure accuracy of essential fact and faithfulness of interpretation in this study, but he has not hesitated to draw freely upon writings such as those of William Morris, Filson Young, Hilaire Belloc and Charles Brooks to give the atmosphere and flavor of the times.

heart." Leonardo was inscribing in pictorial form the new anatomy. In Ruskin's terms these men were polluting their art with the science of the sepulchre. The men of that day looked upon themselves with very much the same satisfaction that we look upon ourselves in this enlightened age. Wonders were developing with dazzling rapidity, and though many held the crack-brained Columbus to be a fool it was but a few years before the vision of the New World burst upon their astonished gaze. "What does the fellow say," wrote Luca Sarto, "but that the world's a globe—that it is shaped like a huge tart and is plattered in space. But also this tart is always spinning, and what lies eastward on the platter whirligigs to west. It is blasphemous coggery. This Christopher Stand-on-His-Head ruffles me."

There is nothing which illustrates better the pinnacle of confidence which was attained by philosophy in the Middle Ages than this fact that a poor man, in a strange land, without knowledge of the classics or the Fathers, having no other argument than his own fixed belief and some vague tales about bits of wood and shipwrecked mariners, should be able ultimately to secure the influence and funds for taking a flotilla right out into the Sea of Darkness and down that curving watery slope up which none ever climbed before.

Yet at the heart of all this prosperity and splendor and activity in thought and art there was a canker, the canker of pestilence. A century and a half earlier, creeping insidiously along the Mediterranean shore, the basilisk had wormed its way into Europe, blasting everything in its path with its poisonous putrid breath.

Upon a morning in 1348 Boccaccio in Florence, looking from his window, saw two hogs rooting among the rags of a poor man just dead, and shaking them about in their mouths, "when they both turned round and died on the spot." The sickening rats rushed from their holes and crevices in troops and "issuing on to the floors sprang continually upwards from their hind legs as if they were trying to jump out of something." Penitent and confessor were borne together to the same grave and the funeral earth, chapped and ghastly, bulged over her new buried corpses.

Petrarch, like his friend Boccaccio, an eye-witness of the Black Death in Italy, foresaw the inability of future generations to imagine the empty houses, abandoned towns, fields crowded with dead, the solitude of the world. "Is it possible that posterity can believe these things," he writes, "when we who have seen them can scarcely believe them."

The black death arrived at the critical moment when English social customs were maintaining with difficulty their traditional form. The problem of villeinage was occupying the public mind. There was no land hunger in those days. The towns had not yet begun to be the dominant factor in civilization. The worker was land bound and sought to be free. So when after 1348 his numbers were reduced by half, in spite of the Statute of Laborers, wages were permanently raised and freedom of migration was secured for the hinds of the manor. As the land owners died and estates fell in, the new yeoman and farmer class, afterwards so powerful in the fifteenth century, grew in strength by the accumulation of recruits from below. The business of the courts greatly increased and pettifogging lawyers, hated by the peasantry, swarmed over the land, "men who had no souls but only parchment deeds and libels of the same." The impetus given to the workers developed the trade guilds of the towns. And so the entire structure of society was convulsed. Settlement awaited the Peasants' Revolt of 1381, but though this was suppressed, the humanizing elements which leapt out of the pestilence could not be defeated and the modern social order struggled at last

into the position in which it remained secure until these troublous times of ours. These were not men of a strange race or culture. The time, though distant across the centuries, is one with ours. And we also can be stirred as were John Nameless and John the Miller and John Carter that early summer evening in 1381 at Mitcham Green, when the reflections of John Ball fell softly on their listening ears. How "men fight and lose the battle, and the thing that they fought for comes about in spite of their defeat, and when it comes turns out not to be what they meant, and other men have to fight for what they meant under another name." "John Ball greeteth you well all and doth you to understand that he hath rungen your bell."

But, intermittently, from that year onward the Black Death scourged all Europe for three hundred years and calamity marched step by step with progress.

The theory of contagion gradually developed itself in the public mind, and by the sixteenth century became the basis of legislation for protection, not of the people in general, but of the court. However, specific measures quickly followed for isolation of the sick and protection of the populace.

The infected house was shut up with a large red cross and "Lord have mercy upon us" painted on the door. Watchmen, attending day and night, prevented any one going out or in except physicians, nurses and searchers prescribed by authority. These precautions were to continue, as the edict had it, until a month after all the family was dead or recovered.

Progress is slow to start and when it moves is apt to trample human hearts. So to the prisoners in the house, "strangers," as Mead wrote in his famous discourse (1720), "to everything but the melancholy sight of the progress Death makes among themselves," "Lord have mercy" must have seemed a curse and the four walls of their prison the very jaws of the tomb itself.

Of the last great plague in England, that of 1666, the newspapers of the day were full. Extracts from these were thrown together by Daniel Defoe, of Stokes Newington, in the form of a journal. This Daniel Defoe, whom we know so much better because he learned the adventures of Alexander Selkirk and went to school as a boy with another little lad called Timothy Crusoe, was a kind of combination of H. G. Wells and Bernard Shaw. They made him church warden knowing that as a dissenter he would rather pay the fine of ten pounds than assume office. Vividly and faithfully does Defoe tell of the people crazed by constant communion with unspeakable death dashing from their houses to end their life in the Thames and so escape the worse horror which drove them on.

Even the incorrigible Mr. Pepys breaks away from his vainglorious jottings to recount how there appeared before himself as magistrate "a very able citizen in Gracious Street, a saddler who had buried all the rest of his children, himself and wife now being shut up and in despair of escaping, who did desire only to save the life of this child; and so prevailed to have it received stark naked into the arms of a friend who brought it to Greenwich, where we did agree it should be permitted to be received and kept."

So in the course of time humanity prevailed. Mead, in 1720, advocated the abandonment of these terrible measures and proposed instead the establishment of hospitals outside the towns and the isolation of cities rather than of homes. It was Mead who persuaded Guy to found the hospital which goes by his name. He was a man of unbounded hospitality, who spent his afternoons in a lucrative high-class practice and his mornings prescribing for patients whom he had never seen, at half guinea fees, on the written or verbal reports of

apothecaries. Mead's reforms were bitterly assailed and the next year nullified by act of Parliament. But of all the hard things said of Mead none surpasses in vigor or in scorn the invective of Noah Webster, the lexicographer, who set to work with a mind enlightened by the sources of words to seek the origin of pestilence. An ill-humored fellow, this Noah, who must have suffered from some kind of duodenal irritation. "Sound potatoes from the market," he writes, "perished in my cellar in thirty-six hours." So from this he goes on to larger issues. "In the United States, everything that has been done hitherto in the construction of cities, is in imitation of the old European mode, and of course is wrong." To such sweeping generalizations may a bad potato lead. Nevertheless even to Noah pestilence was a blessing in disguise, for it "humbles the pride and arrogance of man, by creating in his mind a perpetual dependence on divine power; in short it creates and preserves that sense of obligation and accountability to God which is the germ of piety and moral excellence."

But all journeys end in the twilight and the angelus interceding for preservation from pestilence closes the day. "Sweet scent," writes Luca Sarto, "wards off the plague better than the killing of a hundred Jews."

So I would hark back to my bishop, counselling the rich to leave town, breathing comfort and hope for the poor who, bound by circumstances, may not escape from the overcrowded city. "To be merry in the heart," he says, "is a great remedy for health of the body. Therefore in time of this infirmity beware ye dread not death, but live merrily and hope to live long." Of all documents on the pestilence this is the most moving and the most human. It is the physician as counsellor and sympathetic father-confessor who can see beyond the veil, like John Ball, the hedge priest of 1381, that "he who doeth well in fellowship shall not fail, but in days hereafter shall he and his work yet be alive and men shall be holpen by them to strive again and yet again."

BOTANICAL EXPLORATIONS IN THE ROCKY MOUNTAINS—SELWAY RIVER

By Professor J. E. KIRKWOOD
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THE Bitter Root Mountains extend from Lolo Pass south to the head of the West Fork of the Bitter Root River, a distance of about seventy miles. They parallel the course of the river, which flows north, joining the Clark's Fork of the Columbia near the city of Missoula, Montana. The crest of the Bitter Roots forms part of the boundary between Montana and Idaho. On some of the older maps the Bitter Root Range is shown as extending from the Clark's Fork River to Yellowstone Park, but Lindgren's report on the geology of these mountains, published in 1904, defines the range as above given on the basis of its geological structure.

The Bitter Roots are a rugged and picturesque range, especially toward the southern end, where a lofty and serrated skyline of sharp peaks and castellated ridges rises as a forbidding barrier. Trapper Peak, southwest of Darby, is the highest point, reaching 10,175 feet, while other summits of 9,000 or more occur the whole length of the range. Passes are found here and there at elevations of 6,000 or over, and Lolo Pass is notably low at 5,400. The eastern face of the range is steep, cut by deep and numerous gorges, and rises from the Bitter Root River at an elevation of from 3,300 to 3,600 feet to the summit twenty miles more or less to the west, while the other slope descends by more gradual degrees to the Clearwater country with an average elevation of between 5,000 and 6,000 feet.

The Bitter Root Mountains lie athwart the prevailing winds of the region which come from the west and southwest. These are the rain-bearing winds, resulting in heavy precipitation on the windward side and correspondingly lighter rainfall on the area lying east of the range. The Bitter Root Valley, as a matter of fact, is one of the driest valleys of Montana, with an average annual precipitation of less than eleven inches. The streams flowing eastward from the summit are numerous but short and of small volume, but those flowing to the west converge into two rather large rivers, the Lochsa and the Selway, which are the main sources of the Clearwater, a strong affluent of the Snake.

The difference in the precipitation and the conception of the Bitter Root Range as a potential barrier to the eastward movement of species led to the formulation of plans to examine its flora with two objects in mind: first, the floristic; and second, the distributional aspects of the vegetation. Pacific Coast species of the humid areas of Oregon and Washington are plentifully represented in the favorable localities on the western slope of the northern Rockies. It is of interest to know what part they may have in the flora of the Bitter Roots.

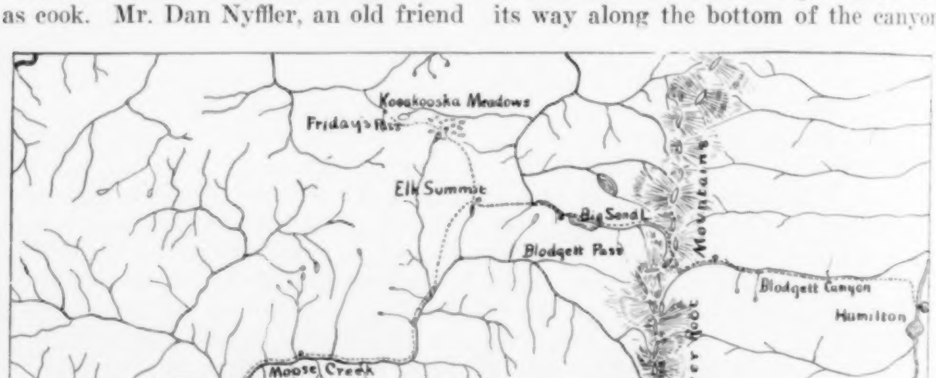
This program involved the crossing of the Bitter Root Range and the traverse of an extensive wilderness little known, except to a few scattered settlers, occasional hunters and a limited number of employees of the U. S. Forest Service. The effort to do this occupied parts of two seasons and took the writer over some three hundred miles of trails. Saddle and pack-horses were the only

means of transportation in a section far removed from even the roughest wagon roads. The Bitter Root Mountains proper lie along the eastern border of this wilderness and shut it off from the older settled regions of western Montana. To the west from the Bitter Root summits it is close to one hundred miles to Kooskia on the Clearwater, the nearest important settlement on the Idaho side. The area, however, to which attention was directed in this brief survey amounts roughly to between 3,500 and 4,000 square miles, including the Bitter Root Mountains and the country thirty miles or more to the west and northwest. The results of this study will appear in a later report. This account will present some of the general aspects of the country and incidents of the trips.

We outfitted at Hamilton, Montana, and secured the services of Ned Hobbs, of that place, as packer. Mr. A. N. Hobbs, father of the packer, volunteered as cook. Mr. Dan Nyffler, an old friend of Ned Hobbs and his guest at the time, also accompanied the outfit and assisted efficiently in the packing. In addition, the personnel of the party consisted of Mr. J. W. Severy, instructor in botany at the State University of Montana, the writer and his son, Edward.

On the morning of the 23rd of August, 1923, we left Hamilton and turned our faces toward the Bitter Root Mountains, which seem to rise almost from the outskirts of the town. Blodgett Canyon opens like a vast portal with perpendicular walls of granite admitting to the secrets of a beyond, to us wild and unknown. In spite of the awe of its magnificence and mystery, our spirits were high and thrilled with eager interest at the prospect before us for the next three weeks. No hint of sinister significance reached us or any forecast of this ill-starred expedition.

Views of fences and farms were soon left behind as the trail began to thread its way along the bottom of the canyon



THE ROUTE TRAVERSED

THE BITTER ROOT MOUNTAINS AND PARTS OF THE BITTER ROOT AND SELWAY DRAINAGE.

BITTER ROOT MOUNTAINS FROM THE WEST

beneath the beetling cliffs, with Blodgett Creek roaring down its rock-strewn course. The trail rose steadily and we were soon out of the yellow pine belt and began to see groups of lodgepole pine and aspen. Subalpine fir and Engelmann spruce then began to appear along the creek. Huckleberry (*V. membranaceum*) and snow-brush (*Menziesia ferruginea*) and clumps of alder (*A. sinuata*) around springs indicated our passing into the main timber belt or montane zone. The day grew hot and we stopped frequently to refresh ourselves with the clear cold water that rushed by at our feet.

The pack train moved steadily onward to the tinkling of bells and the shouts of the packers. Progress was slow, for of all trails encountered before or since over several years, the Blodgett Trail is the worst. Granite boulders tumbled from the cliffs above covered the canyon floor. The horses with their heavy packs stumbled and scrambled over them in imminent danger of breaking legs or pulling off shoes. They labored and sweat and puffed as they advanced under the patient guidance of the packers. Even the unburdened saddle-horses and their riders, now afoot, found enough to do. As the canyon narrowed, we traversed the talus of cliffs or the debris of avalanches thrown confusedly into the bottom of the gorge.

The aim had been to gain the high meadows near Blodgett Pass the first day. But as the afternoon drew on there were still several miles to go. Horses and men were tired, so camp was made with only twelve miles accomplished. Between the trail and the stream on an inviting little flat our first camp was pitched. The trail had risen 2,200 feet above Hamilton but seemed farther from the crest than at the start On either side, in austere and rugged grandeur, towered mighty walls to nearly 3,000 feet above the camp. Around us the somber fir and spruce cast deepening shadows, while the sun's declining glow gilded the lofty peaks. The freshness of early summer was here in leaf and flower, where neither the hot drouth of the valley nor the early frost of autumn had yet reached them.

In the midst of this contemplation sounded the call to dinner. Out of the medley of cans and bags, the magic of the elder Hobbs had conjured a feast to

A FOREST OF YELLOW PINE (*PINUS PONDEROSA*)
COMMON VIEW ON SOUTHERN EXPOSURES IN THE BITTER ROOT MOUNTAINS.

which we now addressed ourselves with appetites born of that laborious trail, of the scented forest and the exhilaration of the evening hour.

Day awoke in the east and the camp was astir ere the sun's level rays had brightened the lofty crests above us. Breakfast was on, the horses were coming in, bedding was rolled and packs made up. When our saddle-horses were ready three of us took the trail, leaving Ned and his father and Dan to pack the horses and follow. This was our usual procedure, which suited all concerned. It gave us in the lead more leisure to make collections, notes and photographs, and we were out of the way of the packers, whose operations we could not materially aid.

A few miles above camp the trail turns abruptly from the creek toward the high northern wall of the canyon. There was no mincing matters here. The summit had to be carried by direct assault, and up we went. First straight ahead over the lower slope and then, as it grew steeper, we swung alternately right and left in a series of sharp "switchbacks" that carried us rapidly far above the floor of the valley. The sharp spires of the firs rose among the spruces along the creek and dwarfed into insignificance as we ascended. A cliff-like wall rose above us, and along the face of this the trail was carved. From this point a panorama spread wide before us. We were now out of the forest and could see far with uninterrupted vision. Our canyon where we had left it began to turn in a broad sweeping curve toward the south, where it took its source in a lake nestled among the

peaks. Its walls of bare and scarred granite presented a deep, rounded, glacial trough. Here the north and west wall of Blodgett Canyon forms the main crest of the Bitter Roots. On and on as far as the eye could reach was a wildly tossing sea of crags and peaks. Down the canyon to the east lay our trail of yesterday—somewhere deep in the chasm among the spruces and firs and tumbled boulders—and away out beyond was the Bitter Root Valley. But the pack train was coming on; we could see them emerging from the woods toward the ascent and knew that our time for viewing the landscape was limited. We turned reluctantly from the vision and addressed ourselves once more to the ascent.

The trail crosses Blodgett Pass at 6,500 feet. Right here we found *Rhododendron albiflorum* and the little *Luetkea pectinata*, both unreported from the Bitter Root Mountains. The top of the range here is a very narrow, rounded ridge. One emerges from the ascent and in less than twenty paces begins a sharp descent on the other side. He passes from a treeless slope suddenly into a luxuriant forest of fir, pine and spruce. Corkscrew-like the trail descends for a few hundred feet and then on a more moderate incline emerges on a beautiful subalpine meadow gorgeous in its array of deep blue gentians (*G. calycosa*). The sound of a little stream comes to our ears. A trench in the meadow sod, fringed with low willows, lush grasses and sedges, carried clear, cold water, dropping rapidly over its stony bed, gaining at every step, on its way to Big Sand Creek. Our trail follows this stream and we descend rapidly. The pack train has already passed us, so we

ENTRANCE TO BLODGETT CANYON

IN THE BITTER ROOT MOUNTAINS. ON THE LEFT, WESTERN YELLOW PINE (*Pinus ponderosa*). SHRUB IN BLOOM IS SERVICE BERRY (*Amelanchier alnifolia*).

BLODGETT CANYON FROM THE BITTER ROOT VALLEY

—*Courtesy of Johnson Studios, Hamilton, Mont.*

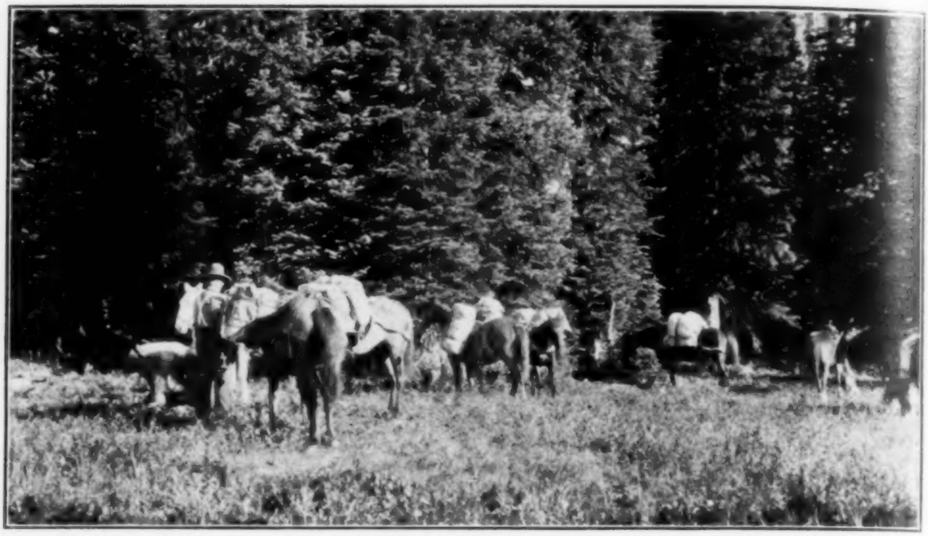
keep moving except as we pause to gather specimens too good to leave. The trail is deeply gullied by flood-waters and progress is slow, but withal it is better going than yesterday.

With decreasing elevation we come onto flatter, drier ground where the lodgepole pine is dominant, and for hours the trail, now much better, leads us steadily westward towards Big Sand Lake. This beautiful body of water lies like a silver mirror fringed by green forest. The silent fir and spruce hedges it round and it seemed as if its placid bosom was never stirred by a passing breeze. We wanted to linger at this enchanted spot, but the shadows were lengthening and there was some distance yet to go before we could find feed for the horses, a necessary consideration at every camp.

The problem of supporting horses on a trip of this sort is an ever-present one. In an open prairie or meadow there is usually little difficulty; the native grasses of many species furnish excellent forage and animals feed contentedly without straying far on such pastures. But most of the area we were now traversing was forested. The forest offers little feed. Most of its plants are lacking in nutritive value. Few grasses occur. The creek bottoms with their thickets of willows and other shrubs are little better than the upland pine forests. Bogs and young meadows around the shores of lakes produce mostly coarse sedges which, although some of them are eaten, are rather unwholesome. In burned areas the growth of weeds and browse is also of little value, and the amount of fallen timber makes difficult access to what is edible. Consequently feed is limited mainly to open glades and meadows where grasses abound, and these are found in their best condition at higher elevations. Horses will not stay on poor feeding grounds and, though hobbled, will sometimes wander miles away during the night, necessitating arduous exertions on the part of the wrangler and entailing delays which are inconvenient and sometimes expensive. Picketing is always inconvenient and risky and, on poor feed, impracticable. Hence the packer must turn his horses loose and trust to bells, barricades and other devices to insure his finding them again. One of the vicissitudes of this trip was the scarcity of feed and the consequent difficulty of keeping our horses within reach. Constant vigilance night and day was required to avoid losing them while feeding and the length of our marches and the duration of our sojourn here or there were dictated by this contingency.

The next day the trail held to the course of the stream for a few miles and then swung to the west, rising along a south-facing slope and burned area to an open green forest on top of a ridge near 7,000 feet. We then began to drop down into a shallow basin and at noon pulled up at Elk Summit Ranger Station. Here is one of the most beautiful and extensive of the mountain "parks," embracing a hundred acres or more, partly level meadow, partly gently rolling slopes dotted with clumps of spruce and fir. Grass grew luxuriantly, and a little stream flowing from a small lake wound its way between low banks. This ideal location lay on the Lochsa-Selway divide. To the east water flowed to the Big Sand and thence to the Lochsa, to the west into Moose Creek and the Selway.

After a brief call on Ranger Bell we pushed on northward to Kooskooska Meadows, about seven miles farther. One of the many trails leading out from Elk Summit was pointed out to us. It led up a gentle slope through an old lodgepole burn. By insensible degrees it passed from the lodgepole pine into the



BREAKING CAMP AT ELK SUMMIT

TREES IN THE BACKGROUND ARE SUBALPINE FIRS.

white bark pine and its carpet of wood rush and clumps of purple mountain heather (*Phyllodoce empetriformis*) and Labrador Tea (*Ledum glandulosum*) and we knew that we were now near 7,000 feet elevation. This elevation of land proved to be a long narrow ridge from the vantage of which we were afforded an excellent view of the west side of the Bitter Roots whose rugged summits formed the eastern skyline. St. Mary's Peak, the Heavenly Twins, El Capitan and Trapper rose in their magnificence in a panorama nearly seventy miles wide across the deep canyon of the Big Sand.

From this ridge the trail dropped rapidly through an open and partially burned forest and emerged at the edge of a wet bog where pools of water alternated with islands of rush and sedge and with the white plumes of the cotton-grass (*Eriophorum*) waving in the breeze. Kooskooska Meadows was originally a small lake formed either in a natural depression or through the work of beavers. Silt and sand carried in by streams and the encroachment of vegetation have resulted in a level area of many acres of heavy turf formed of grasses, sedges, shrubs and other plants, traversed by meandering watercourses, whose channels are often treacherously hidden under overhanging vegetation. Its varied surface displayed different steps in the succession toward the mature stage; first, the aquatic sedges and other plants; then the drier areas occupied by grasses; then the shrubby vegetation. Here also the fir and spruce are dominant and where not killed by fires form a thick and somber forest skirting the edges of the bog. This was what the elder Hobbs deprecatingly called a "moose bog," in allusion to the poor prospect it presented for his horses.

Two days were spent at these meadows. One was devoted to a side trip to Friday's Pass, five or six miles from camp. A couple of saddle-horses were requisitioned, and the writer in company with Mr. Severy set out over the trail that led, *via* this pass, to the Lochsa Canyon. The whole of the distance lay

through a heavily burned area, which presented little of interest except as we neared the pass where some rich subalpine meadows furnished a collection of *Luetkea*, growing in dense flowering mats on a southern exposure. *Campanula Parryi* and species of *Hypericum*, *Senecio* and *Arnica* were also conspicuous in full bloom.

The pass has an altitude of 8,000 feet. Here the trail crosses a grassy glade and descends abruptly toward the Lochsa. A belt of green timber which had escaped the fire consisted mainly of white bark pine (*P. albicaulis*); but a little to one side and above the pass we came upon Lyall's Larch (*L. Lyallii*), the first and only specimens found on the Selway trip.

Beyond the pass and below the peak lies the chain of little Wind Lakes. They are several hundred feet below the pass and were reached by us with some difficulty, clambering down over cliff and talus. They lay in open meadows fringed by grasses and sedges. Our time was short, so after making hurried collections we turned our faces toward camp, well satisfied with the day's experience.

Returning to Elk Summit we established ourselves for a day's stopover in this delightful spot. Here we made good use of the time and fair weather in drying blotters and getting specimens advanced in the curing process. A few things were added to our list, but the lateness of the season necessarily limited the collection.

From here we turned our faces toward the Selway River, distant some twenty-five or thirty miles. The land fell away to Moose Creek in a steep descent through a narrow gorge. This being a difficult and impracticable route is probably the reason why our trail took us over a high ridge to the north of the canyon and then down by a winding way

SUBALPINE MEADOWS AT ELK SUMMIT

TREES WITH THE SPIRE-LIKE CROWNS ARE SUBALPINE FIR (*Abies lasiocarpa*). OTHERS ARE PRINCIPALLY ENGELMANN SPRUCE (*Picea Engelmanni*).

WHITEBARK PINE (*PINUS ALBICAULIS*)
IN FRIDAY'S PASS. ALTITUDE 8,000 FEET. GRANITE BOULDERS.

to the stream some miles below. The westward slope of this mountain was notable in the presence, size and frequency of certain species not met before. The grand fir (*Abies grandis*) and Cascara (*Rhamnus Purshiana*), both partial to moist conditions and moderate temperature, were especially worthy of mention, and the mountain laurel (*Ceanothus velutinus*) attained a height of six to eight feet as against the height of two feet seen in the Bitter Root Valley and elsewhere in dry places in Montana. All these species grow luxuriantly in the Coast Mountains of Oregon and reach larger dimensions than anywhere in the Rockies.

From the foot of the mountain the trail follows Moose Creek along the bottom. This tributary of the Selway heads to the south of Elk Summit and becomes a considerable stream ere it joins the river. Along this stream we soon came upon another expression of the coast conditions in a most interesting and pleasing way. For several miles our trail led through a magnificent stand of arbor vitae (*Thuja plicata*). The huge trunks of these trees, with diameters of three to six feet, rose in tall columns supporting a canopy of foliage through which the sunlight scarcely penetrated. It was practically a pure forest and so dense that few plants grew beneath it. Only the maidenhair fern, which grew in profusion, could really be said to be successful in this deep shade. There formerly were fifteen or twenty miles of this forest before the fires swept through this section. Now about six miles is all that remains untouched. Emerging from the cavernous depths of this green belt into the desolate and weedy burn led us to an acute realization

of the loss to which we were subject through forest fires.

About four o'clock found us at Maple Creek, where we camped for the night. Hours of travelling through the hot sun over a dusty trail made the cold, clear water look good to us, so we stripped and plunged into its icy flow. A few minutes only, but it refreshed us greatly and we dressed and set vigorously about our work of preparing the day's collections from along the trail.

A few miles farther on Moose Creek Canyon opens out into a valley with broad flats where two or three bold settlers are clearing farms out of the wilderness. This pioneer home-building is fraught with much hardship and little profit, but it has its compensations. If income is small, wants also are few and much of the living is yielded by the fertile soil and the abounding fish and game.

Moose Creek joins the Selway River, coming down from the south. At the point of junction the gulches narrow again and both streams emerge to the union from rockbound gorges. The Selway is a beautiful stream. Our trail followed the bluffs along the right bank often high above the stream into whose green and transparent depths we loved to gaze. It was low water and the high water line plainly visible on the rock wall of the chasm was fully twenty feet above the surface of the stream in August. The absence of driftwood and light debris on the immediate banks of this stream bore testimony to the swift current of its high floods, and the immense volume of water which in season pours down this channel indicates the abundance of its sources, largely in melting snow.

Our objective for this day's march was Cedar Camp, about twenty miles from Maple Creek, but upon arrival it was apparent that very little feed could be had for the horses. We were now in the green forest, and at this point especially the deep shade was inviting, but no feed no stop, so we decided to push on until the horses could be taken care of. This took us about three miles farther to the mouth of Meeker Creek, where Mr. Hobbs called a halt with a rather dubious indication that feed might be had on the hills above us. Looking up we could see the bald brows of bluffs facing the south, where the soil, too dry for a forest, bore a scant growth of bunch grasses. It was thought that this probably extended back far enough to afford fair pasture for the animals. Accordingly they were turned out upon the slopes and a barricade erected to keep them from coming down.

This was our eighth day out. We had hoped to continue down the river at least as far as the falls some twenty miles below, but the scarcity of feed made it seem best to turn toward the head of the Selway, which meant retracing our steps as far as the mouth of Moose Creek, where we would turn south up the valley. We were in some doubt as to where our course could profitably be laid and one of our difficulties was in securing adequate information as to trails and feed. Our maps were the best to be had, but they were either incomplete or old and indicated nothing as to the conditions of the trails, which in some cases were found to have been abandoned for years. Oral inquiry was not much better in eliciting dependable information.

At Meeker Creek the altitude is about 2,200 feet. The dryness apparent on the higher exposed slopes indicated our entrance into a different climatic zone, the Arid Transition, which we left at Hamilton, Montana, at 3,600 feet and which prevails generally in the intermountain valleys farther east from 4,000 feet down. Along the Selway at this

FIRE DESOLATION AT MAPLE CREEK

DEAD TREES IN THE FOREGROUND ARE ARBOR VITAE (*Thuja plicata*).

point and in sheltered canyons and on north slopes we found ourselves in company with the grand fir and other plants suggestive of Humid Transition of the Pacific Coast, conditions indicative of greater rainfall and higher relative humidity than obtains east of the Bitter Root Range.

At Meeker Creek our fortunes began to change. Up to this point our trip was pleasant and successful, but the subsequent days were not soon to be forgotten. Dawn had not broken on this camp before the wakeful ear of Dan caught the sound of bells descending the hill. The horses had passed the barricade and were making for the river trail. They must be turned back! Hurriedly rolling out of his blankets and slipping on his shoes he rushed out in his night clothes to reach the point on the trail some distance below the camp, where they seemed to be coming down. Whether the perversity of the beasts or fright at his appearance stampeded them we will never know, but they suc-

ceeded in plunging into the main trail and headed up the river on the run. The trail along the Selway for miles is cut out of the side of the bluffs often precipitous above and below with no chance for detour. There was nothing to do but to follow the animals and trust to an almost impossible chance to get beyond them. Seven miles lay between camp and the mouth of Moose Creek. Here the trail forked and the branch to the right leading up the river crossed a bridge over Moose Creek. At the farther end of this bridge a gate barred the way. Here at last luck favored Dan. The horse is often a stupid animal, and in this case they entered the *cul de sac* and were captured. Returning to camp by eight o'clock Dan refreshed himself by a plunge in the river, and the incident of the horses was dismissed as part of the day's work.

The outfit was soon got in motion and by eleven o'clock we were back at the forks of the trail, passed the bridge and the gate and began the ascent of the Selway Canyon. The Moose Creek Ranger Station was reached about noon. Our coffee had been lost earlier in the trip and we sought here to replenish this article but were refused. The ranger was absent and the youth in charge resisted both our money and our prayers, so we went on our way.

Here also for miles the trail wound in and out around the high bluffs above the stream. The day was hot and the trail being on the slopes facing the west we got the full force of the afternoon sun. None of us felt much enthusiasm, what with the difficulties of the day and the uncertainties as to what lay ahead. Early in the afternoon two of the party, Dan and Edward, showed marked symptoms of illness, and at last we were glad to pull off the trail and make camp at Dog Creek, seven miles above the forks.

We had hardly dismounted when the younger boy fell in a faint. Dan retained consciousness but retired to a hastily

GRAVE PEAK

WITH LOOKOUT STATION ON SUMMIT. ALTITUDE 8,200 FEET. FOREST A MIXTURE OF SUBALPINE FIR (*Abies lasiocarpa*), WHITEBARK PINE (*Pinus albicaulis*) AND LYALL'S LARCH (*Larix Lyallii*).

made bed. Here we were in the heart of the Clearwater wilderness, nearly fifty miles from the nearest wagon road which lay beyond the high Bitter Root Range, and two cases of the dread spotted fever on hand, that swift disease that usually carries off its victims in a few days. For a day or two the boys had been somewhat indisposed but had not given the matter serious consideration. It was now the ninth day after entering Blodgett Canyon, one of the worst localities of spotted fever infection, but at this season generally considered safe. The wood tick (*Dermacentor venustus*), which in the opinion of physicians is generally accredited with the transmission of the disease, is active in the earlier part of the season, but in midsummer passes into a dormant stage. On this trip we saw but one tick and that was not on either of the boys taken ill.

The writer will spare the account of the harrowing days that followed—of our helplessness against the progress of the disease, of the forced march across the Bitter Roots by the shortest route which followed an abandoned trail full of fallen timber, of the anxiety and strain, and of the final passing of brave Dan. We might better dwell on the quiet heroism of Ned Hobbs, on the fine loyalty of Severy, and on the staunch service of a few forest workers who aided us in our extremity. But space here will not permit of the account which may sometime be told more in full.

In the afternoon of the sixteenth day of our trip we reached the foot of Como Lake at the eastern base of the Bitter Root Mountains. Here we made camp. A rough, winding, wagon road comes up from Darby on the Bitter Root River. A message having been sent to Missoula, it was evening when the hum of a motor was heard and the family auto appeared. We now bade farewell to the camp, to the stalwart foresters who had assisted as stretcher bearers, to our good friends, the Hobbses, whose courage and hard work had meant much to us, and turned our backs on those scenes and experiences which we can never forget, but which linger like the impressions of a bad dream. The car rolled down the steep grade to the highway and opened up on the seventy-mile run to Missoula. The dark road was deserted, valley towns one by one were left behind, until we pulled up at home and the Selway trip was over.

The coming of the fever put an end to this botanical enterprise. While systematic record and collections were not made on the return trip the scenes through which we passed remain in the writer's mind strangely as vivid as photographs. The winding trail and its obstructions, the bends and pools and cataracts of the streams, the mountain lakes fringed with fir and spruce, Rock Creek Pass and the towering peak of El Capitan, the camp sites and the serious company, the vegetation and what not. Some old lodgepole affording the finest specimens of the species *Pinus contorta*, ever seen, fine patches of *Aster* and *Solidago* in the mountain meadows, these and others remain still indelibly printed on the memory. On the whole the cross-section of the vegetation represented by the Rock Creek Pass over the Bitter Roots differs little from that of the Blodgett Pass, twenty miles farther north, except perhaps as affected by slightly drier conditions and the thinning out or the absence of certain forms which appear proportional to the increasing humidity with the progress northward.

With this, the somewhat meager account of the Selway excursion, this paper will close. The following season the writer with another outfit crossed the Bitter Roots farther north and examined the vegetation around the sources of the Lochsa and the upper Clearwater. The story of this trip will appear under the title of the Lolo Trail.

WHO INVENTED IT?

By S. C. GILFILLAN
EDGEWATER, N. J.

"Blessings on the man who invented sleep," said the classic Sancho Panza; and the English balladist:

> So I wish in heaven his soul may dwell
> Who first found out the leather bottell.

Perhaps, indeed, he was thinking more of the inner spirit of the bottle, than of its outer integument. Anyway these old-timers express a thought that is common to-day, the rule even, and which not even a single social scientist has shaken himself sufficiently free from, *viz.*, that the great inventions were made by certain great men. We know the names reported for many of the inventors, chiefly Americans, which were taught us in unquestioning youth. Many heroes have been forgot, perhaps, but they were individuals, it is believed, and might be known. Here is Rear-Admiral Bradley A. Fiske, U. S. N., for example, a very distinguished inventor, author of "Invention, the Master-key to Progress" (1921), saying in it that to Dædalus are ascribed the saw, gimlet, plumb-line, ax, wedge, lever, masts and sails. "As no records show to us that the inventions just enumerated (except masts and sails) had been invented elsewhere, we may feel justified in inferring that they were invented in Greece by Dædalus, or by some other man bearing a different name—or by some other men." Not one was. In some of his other passages, to be sure, the Admiral reflects a sounder sense of inventive history.

However, that all inventions were made by certain men, and the great inventions by great men, is the almost universal belief. But here a difficulty at once appears. The famous inventors are called great because such and such an invention is attributed to them. Yet we do not call a commander a great general for gaining one crucial battle, nor a poet great for one perfect poem. For a single achievement, however momentous to us, may have been an accident to its maker.

Now among all the inventors of whom popular history tells, only three, Archimedes, Ericsson and Edison, have been credited with more than one important invention. Others may have equaled them in genius, but not in luck. So leaving aside these three "great inventors," let us take up the "inventors" who did everything else, and later the question of who were really great inventors.

Who invented the telegraph? Any American who has been through the eighth grade knows that it was Morse and Vail, in 1844. But there was an English commercial line seven years earlier, and the Germans credit the telegraph to Sömmering, of Münich, in 1809, and in Switzerland there was an electric telegraph in 1774, and one was proposed in Scotland in 1753. The matter becomes rather confusing for the eighth grade. Who invented the friction match? There are so many claimants that we don't know who the devil invented it, and so have named it after Lucifer. Who devised the aneroid barometer? In Paris in 1848 two men, Vidi and Bourdon, each claimed it, with apparent sincerity, and different courts decided for each of them. But 152 years earlier the philosopher Leibniz had suggested such a barometer, describing it exactly. If we should really examine the roll of honors, from Archimedes,

called the inventor of the pulley, to Marconi and the much overrated Wright brothers, we should find that almost every claim is disputed, and rightly.

The chief reason for this confusion of parentage is that the process of making a great invention is totally different from the common understanding about it. A great invention is not a completed product, issuing at one time from the brain of one inventor. It is a multitudinous collection of little inventions, and is a growth of centuries. Had a single inventor to make the whole, he would need more hands than a monkey, more lives than a cat and more inventive genius than Pallas, Hermes and Loki combined. Let us illustrate this by the history of the steamship.

The first stage of an invention is the beginning of a desire for it. We find the utility of the steamship perceived by Homer, who sang of the marvelous, great, black ships of the Phæacians, which without sail or oar or crew, sped swiftly to the remotest ends of earth, bringing back merchandise. Next, paddle-wheels descend from Roman days. In the thirteenth century Roger Bacon, from his experiments with gunpowder, glimpsed the internal combustion engine, and the means of fulfilling the Homeric desire. He wrote "Art can construct instruments of navigation such that the largest vessels, governed by a single man, will traverse rivers and seas more rapidly than if they were filled with oarsmen." A steamboat had probably been suggested by 1651, and built by 1738, and we have patents with descriptions of 1729 and 1736. But no success was to be expected from such craft, for their engines were wretched. Watt's double-acting expansive steam engine appeared in 1782, and the next year the Marquis de Jouffroy had built a great boat, not fast enough, at Lyons. Before the end of the century steamboats had been built by many inventors, especially Rumsey on the Potomac and Thames, Fitch in the Delaware, who realized good speed and long commercial use, and by Evans, and Miller, who in 1789 made 6 knots on the Forth & Clyde Canal. In 1802 on the same water Symington's *Charlotte Dundas* was a perfect success, save that she washed down the canal's banks. Presently John Stevens, of Hoboken, had speedy steam yachts on the Hudson, even with twin screws, tubular boilers and high pressure, excellent save for the damning workmanship in their motive plant.

Meanwhile Fulton, as we know from direct testimony, had been studying the plans or boats, and interviewing the designers, of every one of the important previous projects, in France, England and America. So had the other inventors been studying, the steamboat evolving out of joint experience; but none were so assiduous as Fulton. In all about thirty steamboats had been built, all in those three countries, generally in the order given. Fulton first built a 66-foot boat on the Seine at Paris, and obtained some speed, but little attention and no success. So he returned to the great rivers of America, and in 1807 launched the *Clermont* in the Hudson, and steamed for Albany at 5 miles per hour.

There was apparently nothing new and valuable about this famous boat. Her engines were from Boulton & Watt, and in no way except in her proportions she was superior to or different from her predecessors. Why then was she more successful? Chiefly because Fulton had, with his forerunner Stevens, made one crucial discovery—the Hudson River—and got a patent on it! It was fitting that we celebrated together the anniversaries of Henry Hudson and Robert Fulton, for each owes his greatest fame to discovering the Hudson River, although each had been preceded by a navigator of its lower waters, and had pioneered more elsewhere. This river was the one best water in the world on

which to run a steamboat. It was the *only* water which combined all the advantages of poor winds (for good winds would mean superior efficiency for sailing vessels), no tow-paths, bad roads, trifling waves, a deep channel, no rapids, a long straight route between centers of commerce, yet paralleled only by bad roads, with an intelligent population, no national boundary, and an abundant fuel supply. I am convinced that the lack of success of several pre-*Clermont* steamboats was mainly due to their faulty environment (and also inferior patent protection). The Hudson was the one proper water for such craft as they; and it is noteworthy that the Hudson has always continued to float the best river steamboats in the world. But a New York paper on the famous day said that Fulton's boat had been invented with a view to navigation of the windless Mississippi—Fitch's aim, which was attained before there was a successful boat in Europe.

I do not mean to disparage Fulton's genius: he was a most brilliant inventor of many other things; but he did not invent the steamboat in the *Clermont*. Nor did he later, for, after rebuilding her at once and ably adapting steam to various types of vessels, and striving to monopolize steam navigation in New York waters (like his successors in accidental fame, the Wright brothers), he died in 1815.

The reader has not been fatigued, we hope, by the voyage of the steamship from Homer to Fulton, for this is only the beginning of her trip, and we can best understand inventions in general by keeping full speed ahead. The *Clermont* was a crazy craft, unseaworthy, and slow as a geologic process. If steamboats had stopped evolving with her they would be as rare and unimportant to-day as dirigible balloons or intelligence in a jury. She is like the ape in our ancestral tree, which we left long ago, and glad we are to have left it. But this was her significance—once it was possible to make money out of steamboats, more and more craft were built, and each brought its little mite, or its valuable contribution, to the art of steam navigation. Each added its inventions, its improvements of detail, which enabled the steamboat to navigate more waters, to be swifter, safer, larger and more economical and effective in every way. So the number of launchings and the rate of progress steadily grew.

About the time of the *Clermont*, Stevens had reverted to low pressure and paddle-wheels, and produced a small vessel of high speed. His *Phoenix*, launched a little later, which first of steamers sailed the sea, and survived a storm, in 1809, when driven by Fulton's patent to the Delaware, was a better ship than the *Clermont*, with a simpler steeple engine and much better lines. She presents excellent evidence of Fulton's non-necessity, for it appears that she was designed chiefly previously and independently, beginning in 1805, and that there was likely as much give as take with Stevens.[1] Thus we may not conjecture, but flatly state, that had Fulton never lived, the first fully successful steamboat would have been launched by the Stevenses at practically the same time and quite the same waters as the *Clermont*.

The ripening art spread slowly, and where most needed. The St. Lawrence knew steam in 1809, and the wild but swift and windless Father of Waters in 1811. Not until the year after that was a steamboat successful on a river of Europe (the Clyde). By 1819 they smote the sea with the resounding paddle, for short coasting jumps. Not until 1840 could they cross the broad Atlantic, with its wind and waves, as efficiently as

[1] Authorities have disagreed as to the date of the *Phoenix'* launch, but it was April 9, 1808, while her independent design is likewise attested by A. D. Turnbull, Stevens' forthcoming biographer.

the sailing packets, and then only for cabin passengers. By 1893 half the world's marine tonnage was steam-propelled, but not yet has the steamship become so perfected as to be better on all voyages than the sailer (also constantly perfected).

A steamship like the *Leviathan* resembles the *Clermont* no more than she does the Flying Dutchman or a quinquireme. Perhaps every principle that was in the *Clermont* is tucked somewhere aboard the modern marine monster, but her 60,000 tons are built up on inventions other and countless, millions of inventions. She has ears beneath the water, wherewith to hear the signals of the sea, when the fog lies over, and she has varied instruments as well to pierce the fog, hearing and making heard. The stockless anchor in her bow is an invention; and so are the machines that forged the mighty links of her chain cables. There are typewriters in her office, and elevators connect her decks. The anti-fouling paint on her keel is an invention, and the tools that made it. Cheap steel, such as makes possible her hull, has been called the greatest of modern inventions; and necessary for that steel were all the instruments, processes and sciences involved, from finding the iron's ore in Lorraine, to devising the giant's thumb and finger, that pinched her plates together with one-inch rivets, and left the surface smooth. Her turbine engines, propellers, endless electrification—these are new. So we might progress from her keel up to the wireless antenna, and find represented in her, or involved ashore, so many inventions that their very descriptions would load the ship. Scarce one of them is indispensable for a great liner, yet all help, and all the millions of them are necessary to make her as she is. Few of these inventions were represented in the *Clermont*. The *Leviathan's* real inventors were half of all the fathers of devices or improvements who have lived since time began. She is a museum of modern civilization, riveted together and called a steamship. Fulton no more invented her than he did the moon. And just so is it with a printing plant, a telephone system or any other so-called great invention—each is the complicated product of a vast and age-old series of inventions in its own and all related fields, due to no one man, nor nation, nor century nor millennium even. An "invention" is simply a certain grouping, defined by an English word, of all the achievements of men's minds since time began. So the "great inventions" were never made by any one—each is perpetually being made.

Why then is there that ridiculous common report, echoed even by inventors and engineers, that Fulton invented the steamship of to-day, or any steamboat? It is a matter of language, and of psychology. People want a definite origin for things. "Jubal: he was the father of all such as handle the harp and organ. And . . . Tubal-cain, an instructor of every artificer in brass and iron." The Greeks gave their thanks to Apollo for the invention of the lyre, if not to Hermes, to whom also they ascribed the alphabet, astronomy, numbers, weights and measures, the syrinx, music, gymnastics, tactics and olive culture. But let us consult a modern authority, the Century Book of Facts (*sic*), "authentic, comprehensive, up-to-date," and published in 1902 in Springfield, Mass., according to the title page, under the editorship of Henry W. Ruoff, M.A., D.C.L. and sometime professor. We read here, along with a typical chronology of modern inventions, that wine was brought from India by Bacchus, weights and measures invented by Phidon in the year 864 B. C., and that the reported inventions of Dædalus, which Admiral Fiske cited, were made in 1240 B. C. What admirable precision! And see Professor Ruoff's cosmopolitan respon-

siveness to the voice of authority: Wheat bread was invented by Ching-Noung, 1998 B. C.; the flute and musical concord by Hyagnis, 1506; "it is, however, agreed that music was first reduced to rules by Jubal, 1800 B. C. "Silk was invented by Se-ling, wife of the Emperor Hoangti, about 2637 B. C. (never mind if authentic Chinese history does begin two millenniums later), and the violin in 5000 B. C. by Ravana, king of Ceylon. But as to weaving the compiler finds some difficulty, for the Egyptians ascribed the art to Isis, the Greeks to Pallas, and the Peruvians to the wife of Manco Capac.

A similar list, with mythology as bad, is to be found in *Le Machinisme Universel,* written in 1925 by Etienne Pacoret, "Ingénieur, Lauréat de sociétés savantes et industrielles," author of seven books on engineering, perfectly competent in the engineering side of this his latest, but innocent of sociology, like the Admiral.

Now simply add an American myth that the steamboat was invented by Fulton. Primitive minds having their similarities, whether in Homeric Greece or Chicago, the recurrent question of whence something came, which it is known did not always exist, is answered by ascribing it to some definite and personal origin. "The telegraph?" Tom says, "why, some one must have invented it—it seems to me I've heard about Morse—yes, it must have been invented by Morse." Not just as a joke, but as an attempt at truer library classification in the Dewey system, I would suggest that grammar school American histories be classified under 292, Mythology, for this and similar reasons.

The fundamentalist assault upon biologic evolution is partly an expression of this same trait of the ordinary mind, which can not so easily conceive and remember the development of a gradual evolution, as a single creation by act of one person.

The popular idea, then, of an invention is a mythologic concept, a personal symbol to account for the origin of something. What determines the personage —why is Fulton called the inventor of the steamship instead of Roger Bacon or Symington or Thornycroft? That man is preferred as the titular inventor who belongs to our own national history, if possible, or to a related country, and who was the first man to make the device a commercial success. Fulton was no more the first man to improve the steamboat than he was the last, but he was the first to make money out of it. He is not deified just because he made money, but because his *Clermont* (with Stevens's *Phoenix*) was indeed a cardinal event in the evolution of the steamship. Previously, building steamboats had seemed a pretty sure way to lose money, so only a few fools built them. After the *Clermont* Fulton had money and reputation whereby to make further experiments, and other men, especially the brilliant R. L. Stevens, were encouraged to build boats elsewhere, to make money. The more boats were built, the more inventions were made thereon, and the faster the steamship evolved. What Fulton achieved, through his lucky step of launching the right sized boat on the right waters, was only to change the steamboat from say 95 per cent. worth while (*i.e.*, from a means of losing money) to 105 per cent. worth while (*i.e.*, a means of gaining money). There is a supremely important economic difference between a 5 per cent. deficit and a 5 per cent. profit—between the number of people who will enter a losing business, and a lucrative one. Yet the genius required to make that small increase of return was no greater than some later inventor's who raised the steampship's usefulness from 8,030 per cent. to 8,040 per cent. We shall speak in another article of the crucial importance of some one's being able to make money out of a contrivance.

Well, so it is with the mythology of each other invention—the Wright Bros. for the airplane, Bell to answer the telephone, Marconi for wireless, are selected out of the millions of their helpers, for having been the men who were conducting an invention, the gradual product of centuries, in that moment when it crossed the dividing line between commercial failure and commercial profit.

We have mentioned the tendency for the titular inventor to hail from the right country. The English believe that the steamboat was invented by Symington, the Scotch call Bell (1812) the father of the steamboat, the French swear by Jouffroy, and the Spaniards have had a thoroughly mythical Blasco de Garay. Mythology does not relish heroes who were foreigners. The American list of inventors allots most of the honors to Americans, and about all the rest to Englishmen (including Marconi who did his work in England). Perhaps these personal symbols, as parts of our national epic, our patriotic religion, are necessary or proper concepts for grammar school children. At any rate they are bound to be propagated while Americanization is the watchword, for they strengthen hero-worship and patriotism, combatting socialism. But at least let those who are old and sane enough to hear such truths about the great inventions as are known to any specialist, not repeat that parrot folly of assigning single personal symbols to the great inventions, on which millions of minds have toiled for centuries, and still toil. There is no more necessity for our believing in such an origin for the sewing-machine than there is for such an origin of man or coats or modern agriculture; and to continue doing so would be equally fatal to all understanding of inventions.

If we desire great inventors to look up to, for learning how to live and labor, let us reverence those discoverers in all lands who through a lifetime of successful inventing showed indomitable perseverance, egregious ingenuity, shining genius. Such heroes include (remembering their lives, not their mythologic attributes), Archimedes, Roger Bacon, the Marquis of Worcester, Watt, Fulton, the Brunels, the Stevenses and Stephensons, Ericsson, Edison, Siemens, Hiram Maxim, Elihu Thomson, Charles Scribner, Steinmetz, Emmet, Coolidge and others who have labored long, avidly and brilliantly to advance human life.

But the common idea that the great inventions have been dependent upon the genius of a single man, so that if the great So-and-so had died of whooping-cough all history would have been different—this idea must now appear erroneous; and it will appear absurd from our further examination into the social process and controls of invention.

BACK TO METHUSELAH?

By PAUL POPENOE
PASADENA, CALIFORNIA

THAT the fountain of youth is just around the corner is one of the most widely heralded of recent discoveries. Man is assured that, thanks to modern medical science, his life is to be immensely prolonged in the near future. Newspaper editorial writers vaguely quote Irving Fisher and Julian Huxley, while they ask whether their subscribers are really ready to use wisely the additional decades that are about to be thrust upon them.

Making the promise more specific, a speaker tells the twentieth annual meeting of the American Sociological Society "that in the year 2,000 A. D., unless we wreck our civilization before that date, many a baby will be born with 200 years or more of life before it; and that men and women 100 years of age will be quite the normal thing, but instead of being wrinkled and crippled they will still be in their vigorous prime."

Such a result would amount to an unprecedented acceleration of evolution; for longevity is an adaptation that fits each species to its conditions of life, removing the adults at a certain time after they have had an opportunity to reproduce.

There has been a gradual evolution in the length of the pre-reproductive period, since the year 1. A bacterium is ready to reproduce after forty minutes of life, a Ph.D. perhaps not until after forty years. During the course of hundreds of millions of years, the general tendency has been, as C. B. Davenport lately pointed out, toward the establishment in mankind of a relatively short uterine period, long childhood, short reproductive period, and long post-reproductive period. But there has apparently not been any very widespread and striking change in any of these respects in historic times, though there have been marked and deleterious changes in them in limited parts of the human race, namely, the most highly educated strata of the most highly civilized nations.

Two or three thousand years ago it appears from the studies of Karl Pearson and W. R. Macdonnell that the expectation of life at birth was ten or twenty years less than at present. At the higher ages, however—say, after sixty—the ancient Roman's expectation of life was probably higher than is that of the American to-day. This was due to the higher selective death-rate in early life, which weeded out the weakest and left only the strongest to survive. The same factor (and not, as Elie Metchnikoff supposed, the drinking of buttermilk) may produce an unusual proportion of centenarians in a rough country like Bulgaria.

Most of the progress of the medical sciences has certainly been within the last two thousand years. It appears that it has not increased the expectation of life at birth more than 100 per cent. at the most; and that long-lived people actually may not, on the average, live as long as they used to. Hence the suggestion that the average span of life may, in the next two or three generations, be increased some 300 per cent. or 400 per cent., involves an unheard-of speeding up of evolution.

Evolution is not a sprint, but an endurance contest. Such bursts of speed have sometimes not been very successful in attaining their goal. One of the outstanding and familiar examples is that of the aborigines of the western hemisphere who, after the arrival of Columbus, tried to cover in a few generations the ground that Europeans had covered in an equal number of millennia, in respect to resistance to certain zymotic diseases and to alcohol. The effort killed nearly all of them. In some localities, as, for instance, Tasmania, there is literally not a single member of the old native race left.

The practicability of such accelerated progress in the case of longevity is urged by Hornell Hart, on the ground that it can already be demonstrated in other aspects of man's power to control his environment. He cites the development of edged tools, transportation, methods of warfare, and the like. But these are social accomplishments, not phases of organic evolution. Indeed, the distinction between inheritance and tradition is precisely that in the latter each generation begins where the preceding one stopped; in the former, each generation begins very nearly where the preceding one began.

And human longevity is very definitely an organic, not a cultural, attribute.

As to the exact mechanism by which mankind is to be enabled to take this running broad jump in its evolution, all the evangelists are a bit vague. They merely point to the lengthening of the average span of life, and by projecting this forward can easily, if they desire, prove that the span asymptotes infinity.

When the facts are examined in more detail, it appears that much of this increase in the average duration of life is, in one sense, merely statistical, resulting from a decrease in infant mortality. If a population is made up of one thousand people who died before the age of one, and one thousand others who became centenarians, it is evident that the average duration of life is some fifty years. If the infant mortality is eliminated, the average duration of life is immediately doubled, though the oldest do not live a day longer than they did under the first hypothesis.

The much vaunted increase in the span of life is therefore partly a reincarnation of one of the commonest statistical bugbears, namely, the misinterpretation of the arithmetical mean.

While the infant mortality has been somewhat decreased in most civilized countries during the last generation or two, the actual gain is by no means as great as it is often represented to be. Part of it is a mere bookkeeping gain, due to the better registration of infant births. The usual measure of infant mortality is a fraction, which consists essentially of the ratio of deaths to births. Deaths, which involve an undertaker and a cemetery, therefore some publicity, have always been registered much more fully than births, which commonly occur in the privacy of the home. Even now there is probably no area in the United States which registers as large a percentage of its births as it does of its deaths. But a vigorous campaign by the Census Bureau and many other agencies has resulted in a steady increase in the efficiency of birth registration. This steadily augments the denominator of the fraction, without changing the numerator, and results in an apparent, though spurious, decrease in the infant mortality rate, even if the proportion in fact does not change.

This is frankly recognized by many public health authorities. Thus the California State Board of Health Weekly Bulletin, November 27, 1926, after mentioning the remarkably low infant mortality rates in some cities of the state, continues:

In some California cities, however, the high infant mortality rates are most deplorable. It would seem that there is little or no community pride in making an effort to salvage these human lives. Undoubtedly the most important factor in the reduction of infant mortality lies in securing thorough registration of all births. This is obvious when it is considered that the infant mortality rate is the proportion of deaths of infants to the total number of live births. If all births are *not* registered, but if all deaths are registered, the infant mortality rate will of course be correspondingly high. The more thoroughly that births are reported in any community the lower its infant mortality rate will be. Next in importance in the production of a low infant mortality rate is the provision of pure milk supplies, etc.

There has doubtless been some real decline in the proportion of deaths under one year, but this is largely counterbalanced by a corresponding increase in deaths between two and five years—an offset on which the infant welfare agencies do not have much to say. Inasmuch as more than one half of *all* deaths are selective, representing the elimination of the least fit, it would be expected that pulling weak babies through the first year would result merely in saving that many more to die in succeeding years—for by inheritance they are not destined to prolonged survival. The studies of Karl Pearson, E. C. Snow, F. S. Crum, Arne Fisher and others leave scarcely a doubt that this is what happens. A decline in the real infant mortality rate is always largely offset by a rise in the child mortality rate.

The changes in the adult death-rates are also equivocal. Speaking broadly, it may be said that the tendency in recent decades has been toward a decline in adult deaths due to infectious diseases and an increase in adult deaths due to degenerative diseases. Both these trends seem to be continuing. The increase in the death-rate from diabetes has been much greater than any other.

To bring about a decline in the death-rate from infectious diseases is, theoretically, not very difficult. It involves such theoretically simple measures as the extermination of a certain species of mosquito, or the destruction within the human body of a certain type of microorganism. A continued gain in the war against such diseases might be expected for a long time to come although the evidence in the case of tuberculosis, which has been combated more vigorously than perhaps any other in the last half century, is not altogether reassuring. In any case, a point must eventually be reached at which the gain will become small, or disappear.

The conquest of the degenerative diseases is theoretically more difficult, for it can not be brought about by any simple vaccination. It must be based largely on a change in the living habits of the race, and it is not so easy to get a middle-aged business man to stop eating and start exercising as it is to clear the hookworms out of his system and immunize him against diphtheria. Conditions appear to be getting worse rather than better, in respect to man's biological habits. While such palliatives as insulin may relieve his sufferings they are, from an evolutionary point of view, merely palliatives. If they change the constitutional make-up of the race, it is likely not to be for the better, since the result is the survival and possible reproduction of persons with weak resistance.

The constitutional make-up is changing in other ways, and it is undoubtedly changing for the worse.

Longevity is well known to be inherited; that is to say, a certain toughness of constitution is passed on from parent to offspring, which enables the survival of the individual even under relatively unfavorable circumstances. On the other hand, even the most favorable surroundings do not insure survival unless one has the constitution. This was well shown by A. Ploetz's study of length of life among the royal and noble families

of Europe, where children have at least never lacked for food and medical attention. There was a regular and close association between the parent's length of life and the death-rate of his offspring.

The gradual increase in length of life, in the course of evolution, has presumably been due, at least partly, to the fact that those who lived the longest (thereby showing their possession of unusually good constitutions) also left the largest number of children to inherit and pass on these good constitutions. Karl Pearson first called attention to the correlation between fertility and longevity, which has since been corroborated by Alexander Graham Bell and others.

The "small family system" has knocked the spokes out of this wheel of evolutionary progress. However great the benefits arising from voluntary parenthood, it has often been pointed out that one racial effect is, under present conditions, disastrous. To diagram the problem, suppose that under the old dispensation a vigorous, long-lived couple had ten children, while a couple coming from defective stock, inheriting weak constitutions, and dying young, had only one. This is not so very far from what actually happened in many cases. Evidently people of sound stock would outnumber people of weak stock ten to one in the succeeding generation; and the race thus evolved toward increased longevity.

But under the present system, which tends to limit every family, no matter how sound the stock, when the priestesses of birth control warn all intelligent people against "breeding like rabbits," while economic and educational conditions make it easier not to breed at all, the situation is changed. The hypothetical weak couple probably still produces its one child; the strong couple produces not ten children, but perhaps two. Thus the strong outnumber the weak in the next generation, not ten to one, but only two to one; and the tendency is for the advantage of the strong to decrease steadily.

In other words, the widespread and severe limitation of births in the better educated and economically successful part of the population results inevitably in a decrease, in each generation, of the average fitness of human constitution. It is against this handicap that medical science must work, in attempting to prolong life. While it gains new technical tools in each generation, it at the same time finds poorer material to work on. The proportion of people in the population with good constitutions becomes progressively smaller; at the same time the habits of life, which need the best of constitutions to withstand, constantly become more unfavorable as the progress of so-called civilization takes mankind farther and farther away from the environment to which it is, biologically, still adapted.

Simultaneously, the germinal constitution of the race seems to be deteriorating through the multiplication of sublethal genetic mutations. Experimental breeding indicates that such mutations are occurring continually, though in small numbers, in any stock. Most of them are recessive, and in a state of nature they are probably eliminated almost as fast as they arise, through close inbreeding and stringent natural selection.

In the human species, close inbreeding is almost a thing of the past, and the intensity of natural selection is somewhat lessened. It is therefore impossible to prevent the dissemination of these injurious mutations. They make the race weaker in each generation, and apparently must continue to do so, for there is no prospect at present that medical science can ever succeed in touching them.

Analyzed thus even superficially, the problem of longevity is so involved that it appears to me scarcely to justify the

optimism that is sometimes generated very easily in public health meetings.

From the clinical point of view, much can be done in individual cases to prolong life. It is this point of view that seems to have been adopted by nearly all who have written on the subject lately.

From the evolutionary point of view, the picture is not so simple. When the clinician's success is in the field of infant mortality, it tends partly to counteract itself by a subsequent increase in child mortality; and also to increase the average weakness of constitution of the adult population. This weakness is at the same time being increased in several other ways. Sooner than is anticipated, the race may reach the position of equilibrium, when the continuing progress of science will find its counterpoise in the continuing decline of man's inherent fitness.

No matter how great one imagines the future progress of science to be, it is not likely altogether to abolish natural selection, any more than Einstein's revision of Newton's laws of gravitation enabled his pupils to lift themselves by their own bootstraps.

Until man becomes an angel, he will remain an animal and continue to reproduce organically. It is, then, still open to question whether the average span of life can be greatly and permanently increased by any agency except eugenics.

THE GRASSHOPPER PLAGUE OF 1866 IN KANSAS

By Dr. WILEY BRITTON

KANSAS CITY

FROM the earliest recorded time, communities of the human race have been afflicted by different kinds of plagues, in some instances wiping out large populations.

In the first chapter of "The Iliad" there is a description of a plague that afflicted the Grecian army when it was on the point of sailing for Troy to open the Trojan war.

Nine days throughout the camp his arrows flew.

In that age of the world all plagues and disasters were charged to the leaders of the people disobeying some oracle, prophet or seer who claimed inspiration from the god of the nation and who was offended by the disobedience alleged.

In Biblical times there is also mentioned in several of the books of the Old Testament brief accounts of plagues, as "There died of the plague 24,000."—Numbers xxv, 9. There is also mentioned a plague of locusts in Egypt, which some writers have interpreted as the same kind of plague as our Kansas grasshoppers.

The Kansas plague of grasshoppers was attributed by the leaders of religious thought at that time to the anger of the Christian Deity who sent it as a punishment for the sins of the people. These same leaders of religious thought, the dominant thought and influence up to recent times, have attributed all other plagues and disasters to the anger or displeasure of their Deity, who sent them as punishments of the communities for their sins of omission or commission.

The priests or preachers of the time who claimed to be in touch with the Giver of all good things offered up prayers for the abatement of the plague of grasshoppers, but there was no abatement until the hoppers had destroyed every living green thing out of doors in a swath more than one hundred miles wide from the northwest to the southeast part of the state, and when they came to the western line of Missouri they commenced weakening and fell upon the earth, and scarcely a hopper passed the eastern line of any of the western counties of the state.

It is certain, and remarks were made at the time, that the people of western Missouri did not suffer any serious effects from the plague like the people of Kansas; yet no Kansan at that time would have admitted that Missourians were spiritually better than Kansans.

In the evolution of intelligence and a broader view of the universe and man's place in it, there is being developed a saner view of plagues and disasters of all kinds from floods, fires and accidents, and instead of charging them to an angry and offended Deity, men are turning more and more to science for explanations. Many things that were once held to be due to an inscrutable power are now considered due to natural causes. In the last sixty years there has been a wonderful change in the views of men in regard to their relations to the universe and to each other.

While we have good people among us who have not yet outgrown their anthropomorphic conceptions of the universe, many of them do not appear as certain of their positions as formerly.

Men of science have not only given satisfactory and rational explanations of the plagues and disasters which have not only from the dawn of history, but from pre-historic times, afflicted the human race, but they have in the most civilized countries for more than a generation been devising ways and means for fighting the agencies of these afflictions until the common man is beginning to depend more on their efforts for relief than on the prayers of the holy man.

Suppose that a farmer's hogs have been exposed to hog cholera; instead of going to his preacher to save them from the disease, he goes to the veterinarian and bacteriologist and secures a serum for their treatment; if his child has been bitten by a rabid dog, he goes to the hospital and asks for the Pasteur treatment to make it immune from the disease instead of folding his hands in prayer to await the result. We need not multiply instances of this kind; they are familiar to every one who stops to think of the changed situation.

Every species of animal, bird, insect or parasite has its enemies, and science in the hands of patient investigators is now using species that are enemies of species that are enemies of man to attack and destroy his enemies.

For four years there have been migratory hordes of grasshoppers from Argentina to Mexico, and wherever they have alighted destroyed everything edible in sight in an incredibly short time. And like the Kansas grasshopper plague of 1866, they come in such vast swarms, a seething living mass, that they dim the light of the sun for seconds at a time. But the problem of controlling their destructive visitations has not appeared too great for scientists to handle. They have found natural enemies of the grasshopper; they have found a parasitic fly, a swift flying fly, that overtakes the grasshoppers and deposits maggots on their backs, and the maggots at once begin eating into the bodies of the grasshoppers and promise to check their migrations.

This opens up an endless field of investigation for scientists to find parasites harmless to man, but deadly enemies to his enemies. In his war on the enemies of man in recent times large or small, the scientists have been uniformly successful, either destroying the enemies or rendering their attacks harmless.

So great has been the success of scientific men in controlling or stamping out enemy attacks from the minutest parasite to animal migrations that the average length of life of man in the civilized countries has almost doubled during the last century.

Almost from the beginning of the warfare of science against plagues and pests of human kind, there has been bitter antagonism of good and devout men against the efforts of scientists to control or destroy the agencies of affliction sent by the offended priest of Apollo or the Christian Deity.

We all know that in the early efforts of the followers of Dr. Jenner to stamp out smallpox by vaccination there was much opposition by those who believed it was flying in the face of Providence or a scheme to thwart the divine will. Indeed there has been decided opposition in some communities in recent years to vaccination against smallpox on account of religious scruples, many believing that it was sinful to oppose afflictions the Christian Deity was pleased to send.

The writer was living at Fort Scott, Kansas, during the grasshopper plague in September, 1866, and observed it every day while it lasted. We had notice of the appearance of the pests in northwestern Kansas several days before the advance arrived at Fort Scott, and were prepared for the sight which no one then living had witnessed before.

The first day the grasshoppers commenced arriving only a few were seen alighting and hopping about on the

streets, but they increased in numbers for three or four days until the air was literally alive with them as far as the eyes could see, a seething, living mass that dimmed the light of the sun at intervals for seconds at a time. It was an impressive and interesting sight.

After a week or so their flight gradually decreased until the early days of October, when they were not noticed in flight, but the bare spaces of ground where they alighted were alive with them, and it was on these spaces where they deposited their eggs in countless thousands; in places they must have been two or three layers deep. In their nesting places on the ground they soon became inactive and dormant and paid little attention to anything near them, and were picked up in large numbers by birds and other natural enemies.

They were not noticeable in movements after the first freezing weather came, but in a short time after their arrival they had devoured all edible vegetation, as the gardens, wheat fields, green corn blades, and the foliage of the trees and shrubs. We had in our garden of about one hundred feet square some fine growing cabbage and they attacked them the first day, and by the evening of the second day they had stripped them, leaving only the bare stalks.

The farmers in that part of the state generally sowed their wheat in September and the hoppers attacked the plant as it came up, and not a field escaped destruction.

They deposited their eggs in the ground in such large numbers that there was fear that when spring came with warm weather and they hatched out they would destroy the growing crops of corn, wheat and oats and all growing vegetation.

The next spring, the latter part of May, the eggs commenced hatching, and in a few days they multiplied in countless numbers, hopping about everywhere but doing very little damage to gardens and vegetation and in the fields. This stage lasted until the early days of June, when they had developed wings and sufficient strength to enable them to fly, and it was asserted by many persons that on a given hour they were seized with a sudden impulse and rose *en masse* and flew away to the northwest, the direction from which the invasion had come the fall before. The writer does not vouch for the sudden impulse of the young hoppers, but he does know that their disappearance from that section was quite sudden, and that after their reported flight they were not further seen, to the great relief of everybody, for fear of the destruction of the growing crops was almost universally entertained by the people.

Whether they had an instinct that caused them to migrate *en masse* like the wild passenger pigeon from southern Missouri in the early eighties we are not prepared to say. As an evidence of their sudden disappearance, it may be stated that no complaints were heard from the farmers of any damage to the growing crops of corn, wheat and oats that season.

As to the origin of the migration in the latter part of the summer of 1866, it was the common report that it started far in the northwest in the foothills of the Rocky Mountains, and we heard almost daily of its progress southeast until they reached southeast Kansas where their flight practically ended.

Since that time the all-seeing eye of the Government, through its agricultural and health departments, has been on the lookout for all kinds of enemies of the farmer and of the people at large, and the moment one is reported, ascertain the facts and declare war on it, the Congress making adequate appropriations of money to carry on the war as vigorously as if the country were attacked by human

foes. Experiment stations were afterward established in all the states and provided with laboratories with the latest technique for making investigations complete under the eyes of experts in any given field of threatened danger.

The latest appropriation made by the Congress of this kind is one of ten million dollars for fighting the corn borer, a European pest which has lately been introduced into this country and which was considered very difficult to attack effectively.

How different to-day is the spirit of the people in meeting the attacks of plagues, pests and disasters, in the home or on the farm, from what it was sixty years ago. It is interesting to one living now who witnessed the events of that time.

Very little effort was made up to that time by the agricultural department, by the state or general government to ascertain the cause and source of migration of the grasshoppers, information which was essential before any plan could be undertaken for the control or destruction of the pests.

As previously stated, the leaders of religious thought, then the dominating influence in dealing with all kinds of disasters, pests and plagues, the enemies of mankind, advised the offering up of prayers to the Giver of all good things, to stay the devastation everywhere visible, and of course the devastation was stayed when there was nothing further edible for the pests to destroy.

No one seems to have thought anything about plagues of any kind being proper subjects for scientific investigation, for at that time science had entered into very few fields of investigation along that line, vaccination against smallpox being the most prominent.

Many Christian ministers preached against science and claimed that it fostered skepticism and unbelief in the scriptures. Those who believed in the efficacy of prayer could claim victory of routing the evil one, for the cold winter had frozen the grasshoppers and the birds and other enemies devoured them so that they were no longer a menace to the community. While it was claimed that the plague was sent by an offended deity as a punishment for the sins of the people, no specific and flagrant sin was mentioned.

The only discordant view about the matter was that the people of Kansas were a little sore at the deity for singling them out for punishment, whereas the people of Missouri, notoriously hard-hearted and sinful, were permitted to escape punishment, for the moment the hoppers in their flight came to the western line of Missouri they commenced to weaken and fell upon the ground paralyzed, and scarcely any passed the eastern line of the western counties of the state.

Since the grasshopper plague of sixty years ago there has been a wonderful development of the scientific spirit among the leading nations of the civilized world, and the scientists have with one accord rejected the view that the migrations of these destructive pests and the breaking out of many parasitic diseases are tokens of the displeasure of the deity who sends them as punishments for the sins of the people, but they hold that these scourges have been due to natural causes and by the aid of science may be prevented or controlled.

The scientists of the present day not only reject the primitive ideas and explanations of the afflictions that have fallen upon large communities of our race in past ages, but they have undertaken to investigate their natural causes, and by careful and patient experimentation have worked out the life-histories of many destructive parasites and developed measures for their destruction or control.

We no longer fear outbreaks of yellow fever or of plagues like the black death plague of the fourteenth century that took a toll of more than fifty million lives of the countries of Europe and almost depopulated some of the large cities, and why? Because when a single case of yellow fever has been discovered our health departments get busy and commence to clean up and to destroy the mosquito *stegomyia fasciata* in its breeding places in the ponds, lagoons and stagnant waters near human habitations, thus preventing the spread of the disease.

If in a single case plague appears and the parasite is properly identified, we at once commence destroying the rats carrying the rat fleas whose bites of human beings inoculate them with bacillus pestis, the destructive parasite, thus preventing the outbreak of the plague. And so we might go on with an indefinite number of preventative and curative measures which have been worked out by scientists for the prevention and control of diseases that once afflicted large sections of our race without any rational effort being made for the prevention or control of the afflicting agencies.

Let us return for a moment to the consideration of migrations of flying insects, the feathered tribes and animals, large and small. We are all familiar with the seasonal migrations of fowl, as wild geese, brant and crane and of wild buffalo, due to climatic influences and in search of food.

The pressure of populations on food supplies and failing food supplies have probably always been a potent factor in migrations of insects and animals, including the human species, sometimes aided by climatic influences. Nor have there been very long intervals of time between some kind of migrations in some part of the world.

At the present time the attention of this country is focussed on the migration of mice in Kern County, California, and the destruction of grain and everything edible in the path of the millions upon millions of mice. From the latest available reports the migration of the mice has already cost the people of the invaded district more than half a million dollars, and it is impossible to estimate what it will cost before the plague has been brought under control. The state and United States authorities have taken a hand in waging war for the destruction of the mice, and the ways and means devised promise success. The deadly poison of strychnine laid about the alfalfa planted areas where the mice were feeding killed them by millions and seemed effective in exterminating them. Cats and other enemies of the mice, turned loose among them, fled from the vast horde without attempting their slaughter.

Field mice are not only incessant feeders on grain, root crops and vegetables and other products of the farm, but they are prolific breeders. It has been estimated that the increase from a pair of field mice, if all breed and live, is more than a million individuals in a year.

A mouse plague in parts of France has been so serious that the Pasteur Institute has been called upon for assistance to control it, and the institute has been experimenting with a disease that kills off the mice in three days. It is stated that grain should be soaked in a solution containing the bacilli which causes the disease. When the mice eat the grain they soon take the disease and rapidly transfer it to others. This is probably the most effective control of the plague that has been tried out, and may be extremely useful in fighting similar plagues in other parts of the world.

There seems to be an increasing tendency of men of science, when they find a parasite doing great damage to animal or vegetable life, to make every effort to find another parasite that is harmless to

such life, to attack and destroy the injurious ones.

In their war on parasitic enemies of man the scientists have already accomplished much, but if they further succeed in using harmless parasites, harmless to the interests of man, to destroy deadly and injurious ones, they will have accomplished still greater wonders.

The mouse plague in California could not probably have been abated by the people of the invaded territory without assistance from the outside, the state and the United States, and they probably would have been obliged to abandon their homes had they not received such assistance.

We are coming more and more to realize the possibility, and even the probability, that national migrations of peoples of past ages were due to attacks on their food supplies by enemies in the form of insects, parasites or animals, like the mouse plague of California, which the people were unable to control.

Before the development of science as we know it, it must have been impossible for many peoples to have successfully met some of the plagues we have had to cope with in the memory of some of our oldest people, and famine or migration would seem to be the only course left to such afflicted peoples.

THE BOTANY OF MARCELLO MALPIGHI, DOCTOR OF MEDICINE

By Dr. FLORA MURRAY SCOTT

FOR the mind of man is drawn to those things that are more difficult and more perfect, the things that minister to man's need, and are held in high esteem. The years pass on, and mind and body fail in strength. The way that has been trodden seems vain, and a new road to learning is sought. But the weariness of age laughs this to scorn. At the end of the day a few stray fragments of knowledge are left, tempest tossed and in wild disarray, and no man's work is perfected. To me, most learned colleagues, I confess that it has happened so. In the burning heat of youth, I plunged into the study of anatomy. Then as I was curious about certain particular things I turned to the study of the higher animals, intent on making these matters plain. But no light came. And I found that only by comparison with simpler forms could I make any headway. So I next tried the insect world, and this too had its difficulties. And last of all I came to plants, for I thought that if I mastered these, I might retrace my steps upwards to the higher forms, and clear the path of my earliest studies. Nor was this yet enough, for beyond the world of plants there lie in wait still simpler substances, minerals and elements. But this is a boundless task and all too vast for my strength.

Here the indomitable urge to know, the keynote of the career of Marcello Malpighi, which set him apart from his fellows as a leader of scientific thought and investigation in the seventeenth century.

Born on March 10, 1628, at Crevalcore, near Bologna, the son of well-to-do parents, Malpighi was educated in his native city. After a few years of liberal education, at that time the study of philosophy, he entered the university as a student of medicine. There he at once came to the fore, and was a notable member of Massari's group of nine. On graduation he practiced and taught for a couple of years, until his appointment to the chair of theoretical medicine at Pisa. To Pisa he owed his friendship with the temperamental Borelli, and to Borelli his nearer acquaintance with the current problems of physics. After a few years in Pisa, during which his health was far from good, he accepted the chair of medicine in the rapidly growing University of Messina at a salary by no means slender for those days. His stay at Messina has been called by Foster[1] the germinal period of his career. For here it was during a time of comparative peace that there arose in his mind those queries and theories, the attempted solution of which was destined to fill the rest of his career. Already at Messina his name as an original investigator had gone abroad, and he had been invited to join the recently inaugurated Royal Society of London. Four years later, while on a visit to his native city, he was claimed by the Medical Faculty of his Alma Mater, and was released by Messina only with much protestation and regret.

I then arranged my domestic affairs in Bologna, and set to work in a frame of mind at the same time calm and keen. My time was absorbed by reading in the forenoons, and in looking after my patients in the city and in the country. I attended dissections, and all the time from an examination of the living and a study of the dead, I tried to fathom the causes of disease. Meantime I kept up a constant intercourse with my friends, especially those from abroad who happened to be passing through Bologna . . . and in discussion I tried to learn more of anatomy and of the remedies for disease. . . .

[1] Foster, Sir M. "Lectures on the history of physiology," 1901.

This last remark is characteristic of the unassuming simplicity of the already famous scientist.

Brilliantly successful and smooth on the surface as Malpighi's academic life appeared, yet it was not without its untoward happenings. Frail health constantly hampered his activities, and the life-long vendetta of the Sbaraglia family, also resident in Bologna, was a constant source of strain. The latter indeed considered it perfectly fitting to molest and to terrorize the aged professor and his wife when they were living with but scant attendance in the country.

At the age of sixty-four years, Malpighi was uprooted from his beloved Bologna and was summoned to Rome as papal physician to Innocent XII, which position he held until his death three years later, in 1694.

From the incessant demands of the dual life of physician and teacher, Malpighi was wont to retreat to the country whenever possible, passing the time occasionally with friends, but for the most part in his own home. There "freed from the troublesome practice of medicine," he could enjoy the "peace of the country" and meantime devote himself to the recently invented microscope. To Robert Hooke the microscope had already revealed the structure of cork, to Leeuwenhoek animalcules many and various. Naturalists both were these, discursive in their interests and observations. The microscope was in sooth a pretty toy, and there were very many things to be seen in the world at once curious and delightful, if, be it confessed, at times a trifle disconcerting. In the hands of Malpighi, trained anatomist and physician, the microscope with its ever-increasing intensity of vision, became at once an instrument instinct with power.

In the seventeenth century, an age of incipient realism in science, the authority of the written word was early doomed. To see with the bodily eye was to believe, and the comfortable faith of an earlier day in the world of spirits, natural, animal and vital, passed straightway into a slow decline.

In no field of science was the turn of the tide more manifest than in the theory and practice of medicine. The circulation of the blood, enunciated clearly, and for the first time proved by Harvey, was further corroborated and supplied with an accurate physical foundation by Malpighi's discovery of the capillaries. Nutrition, respiration, excretion and reproduction, in short all the functions of the body, can only be considered in reference to the circulation of the blood. Thus a new trend was given to current medical thought. Ferments luckily there still were in plenty to serve as the ever useful unknown quantities responsible for the specific functioning of individual organs. Ferments and the process of fermentation, the latter akin perhaps to the bubbling of fermenting wine, or again perhaps to the chemical exuberance of interacting acid and chalk, served their day and generation, until, on meeting the nemesis of a subtler chemistry, they passed along, even as their more spiritual forebears, to the limbo of concepts forgotten.

While these same ferments were playing their part on the scientific stage, muscle fibers and nerves, veins and arteries, capillaries, glands and their ducts, lymph vessels and lacteals, with the aid of scalpel and lens were being distinguished each from each, and anent their exact function many theories arose.

It is not within the scope of this paper, however, to discuss the work of Malpighi, physiologist, anatomist and histologist. Primarily physician, as we must perforce acknowledge him to be, yet nothing, we find, is beyond the curiosity of Malpighi, biologist. The Royal Society in the fever of its youth is interested in receiving communications on all possible subjects of scientific interest, and Malpighi is numbered among their untiring corre-

spondents. And the work of his hand and brain is not "of the stuff that dreams are made of." A multitude of careful diagrams and a wealth of experimental detail give to his scientific foes data sufficient to repeat his work and thereby to corroborate or to refute his statements. And so we find him discussing now the structure of the lungs and the nature of blood, now the viscera of the higher and lower animals and the histology of glands and bones and teeth. He enquires into the sense of taste and of touch and the nature of the grey matter of the brain. The anatomy of the silkworm is one of his earliest studies and the firefly at a later date excites his wondering admiration. And ever and anon he busies himself with the nature of plants, their structure and economy, their growth and reproduction, the "seeds" of lichens and mosses and ferns, the habits of parasites and climbing plants, the marvelously curious insect galls and the disturbances they cause in the normal nutrition of the plant. Nor must we forget Malpighi's contribution to the foundation of embryology, a detailed account of the development of the chick.

It is during his stay at Messina apparently that his interest in the structure of plants is thoroughly aroused. The breathing of insects is accomplished by means of slender tubes, exact miniatures of the windpipes of the higher animal and hence called tracheae. What can be more significant than the fact that, in a chestnut twig there are visible these very same tracheae? And the rest of the plant body, what of that? Where are the counterparts of animal viscera and reproductive organs?

Throughout the whole of Malpighi's botany there is working the mind of the biologist, secure in the belief that all living things are similar in their functioning, and that in plants and animals, therefore, there are to be discerned equivalent structures. A zeal for pretty comparisons here carries Malpighi somewhat far along imagination's highroad, as in his account of the structure of the seed. But microscopes in those days, be it remembered, though perhaps some eighteen inches high, were not necessarily accurate in proportion to their stature.

Dissection and maceration had accomplished much towards an understanding of animal structure. To dissection and maceration, therefore, Malpighi turns for the elucidation of plant anatomy. Microscopic sections, transverse, longitudinal radial and longitudinal tangential are made "with rude instruments enough," and in the case of certain succulent plants, *e.g.*, the *cactus Opuntia*, the method of maceration is invoked. No part of the plant is spared. Stem, leaf, root, bud, flower, seed, seedling and insect gall, all fall in turn to the dissecting blade. "Nature in building the world of plants is not confined to the use of one scheme only, but underlying her work as a whole there runs a certain thread of uniformity."

So we read as we go on to consider the structure of the plant shoot. Further in particular regard to the stem of the vine:

A stem consists of two parts, cortex, and wood. (To Malpighi the cortex is that part of the stem outside the woody cylinder, including to-day epidermis and cork, cortex, endodermis and pericycle, phloem and cambium.) In a vine stem a few months old there is present a wide cortex, the outer cells of which have decayed and dried, thus forming an epidermis. The cortical cells vary in shape. Within the cortex there occur various fibrous strands (bast fibers) . . . which strands anastomosing, are seen in longitudinal section to form a net. The meshes of this net are filled with horizontal rows of cells (medullary rays) while the strands themselves are made up of woody fibers . . . very closely packed together. Within the cortex lies the woody part of the stem. There penetrates this the said (medullary) rays. Some of these reach the pith, others fall short of it. The cells of the pith resemble those of the cortex, but may be larger in size. The woody part of the stem consists of a ring of wedge-shaped (vascular) bundles, separated by (medullary) rays, the apex of the wedges pointing towards the center of the stem.

Tracheae (spiral vessels) of varying diameter, heavily surrounded by woody fibers, . . . along with the intercalary (medullary) rays, are the elements which make up the wood. . . . I was unable in the vine to see any laticiferous vessels. . . .

The parenchyma of the stem consists of "small sacklets or utricles, spherical or oval in shape, thin-walled and filled with diaphanous sap."

The "woody fibers" (of wood and bast) are elongated tubes of varying diameter, whose direction is not strictly vertical, and which open into each other. The "inner cortex" (*i.e.*, the zone immediately external to the woody cylinder, therefore in the normal position of the cambium) is the most important part of the stem, because in it secondary thickening with the formation of annual rings takes place. The young wood is at first soft in texture, but with the inflow of sap it becomes hard.

The "tracheae" or "spiral vessels" resemble closely the breathing tubes seen in insects, but in place of the rings in these tubes, "the inner surface of the vessel is roughened by a silvery spiral ribbon. When a stem is broken across this ribbon may be drawn out, and if this happens in spring to a young green twig, then a peristaltic movement in it may be observed, and this is a pretty sight. Perhaps the movement of the sensitive plant may be due to this capacity."

Of such elements, then, is the plant built up, elements which recur in leaf, root, flower, bud and seed. To Malpighi, however, anatomy is not an end in itself, but merely a road that may lead towards an understanding of physiology, whether of plant or animal.

"Since plants are placed in the number of living things which feed and grow and beget their kind, their life is as the life of animals. Alike in purpose as in function, nature has endowed both with similar structures."

"In the higher animals new food enters the veins in the form of chyle. Here it mingles with the ferments, the lymph and other substances of the old blood, and in the blood stream it circulates unceasingly throughout the various parts of the body. It is thence recollected, and enriched by the ferments it has acquired, enables the animal functions of nutrition and excretion to be carried on."

Turning to the plant Malpighi notes that it consists of roots and shoot. The roots are buried in the soil, and by the roots a crude sap is absorbed. The roots, therefore, in the lap of the soil, are the viscera of the plant.

From the roots the crude sap is conveyed in the woody vessels to the shoot. In the (parenchyma) cells of stem (and leaves) it is mingled with the crude sap already present, and becomes exalted to the nature of a ferment-like substance. . . . The process of fermentation is assisted not a little by the heat of the outer air. . . . The elaborated sap may either be retained in the (parenchyma) cells of the shoot, ready for the future development of buds and leaves, or it may pass down to the roots, . . . as it does in the case of those plants which are possessed of bulbs.

The absorption of crude sap by the roots and its elaboration in the shoot are then, according to Malpighi, the essentials of plant nutrition. That this manufacture of food is carried on in the green cells only, is the discovery of a later day.

From a consideration of structure Malpighi reaches the conclusion that, while food elaboration is vastly important, it is not, however, the sole function of the leaf.

To what parts of an animal do the leaves correspond? . . . obviously not to the muscles, since plants do not move from place to place. . . . Nor to the entrails, since the alimentary canal deals with chyle preparation, a function of the plant roots in the lap of the earth. . . . possibly then to the skin? . . . For the animal skin is a tissue of nerves and veins and arteries, lymph vessels, tendons and glands, a tissue permeated by nutritive sap. . . . This sap, through the glands, gets rid of waste material, and meantime also acquires new ferments. From the skin it returns to nourish the inward parts of the body.

The leaf is a tissue of tracheae and fibers and special canals, and on the surface, there are glands in abundance and also hairs. The whole is suffused with nutritive sap. . . . From the glands and the hairs there escapes the waste of sweat and slow humors. . . . Thus purified, the thorough cooking of the liquid makes it a more perfect food.

A further analogy between leaf and skin is seen by Malpighi in the lower animals. Insects, for instance, during growth, frequently shed their skin. This is paralleled in trees by the annual fall of withered and useless leaves.

The means by which water enters the root, and once admitted, how it mounts to the tip of the highest tree, are intricate problems then as now.

The roots of the plant are buried in the soil and serve for anchorage and absorption. They branch repeatedly and end in fine capillaries. The youngest roots are covered with a fur of soft root hairs to which soil particles adhere very closely. . . . As water percolates through the soil, the salts in the soil are dissolved. . . . How these liquids are absorbed is still in doubt. Where are the gates or open mouths through which the rising liquid is strained? . . . Perhaps the root hairs, very delicate open tubules, pass the fluid inward to the woody fibers, or perhaps, when root hairs are absent, water is absorbed by the skin, and passed thence to the underlying cells. . . .

Changing temperature, with ensuing rarefaction and condensation of the air causing intermittent pulsation, . . . is mentioned as one of the factors in the ascent of sap and the roughness of the inner surface of the vessels is also considered as of interest in this connection.

All living things breathe, insects by tracheae, likewise plants. To what end this apparently indispensable respiration?

So necessary is respiration to life that nature has endowed all orders of creatures with instruments called lungs. Analogous as are these organs, yet they are not wholly alike. . . . For in these animals which we term "higher," the lung capacity is less than it is in the "lower" forms. Man, for instance, in common with other quadrupeds, has two lungs, through which the blood is constantly streaming. In birds the abdominal cavity functions also in addition. With regard to fish, nature is equally industrious, for they are furnished with many rows of gills. . . . Nor are there lungs wanting in shellfish and crustaceans, and here they are often seen to be bigger than the rest of the animal's body. In the latter, of course, respiration is carried on in the water. . . . Coming now to insects, still lower in the scale, we see that the surface of the lung far exceeds that of all the other parts. In butterflies, for instance, I have made out eight or ten lungs which are not, as in us and other air-breathing animals, confined to their proper cavity, but are in the form of long winding tracheae, . . . which ramify like blood vessels in every part of the body. . . . These lungs, present throughout the whole kingdom of living things, are bathed within and without by various fluids. From these they extract the fundamental essence of life. This is furnished to us and to the rest of the higher terrestrial animals, also to the insects, by the air. . . . Fish, crustaceans and other water things extract this breathing substance from the water. . . .

Now since plants are lower than the least of the animals, . . . therefore in them is seen a lavish development of tracheae, . . . penetrating all the minutest parts of the plant, with the exception of the cortex.

We may assume from this that plants, living organisms with their viscera fixed in the ground, must here obtain the material for their respiration, or rather from the air and water that is percolating therein, . . . and that their tracheae are thus filled with the breath of the soil. . . . In regard then to the lungs of the plant, . . . it is probable that the woody fibers, which cling like ivy to the tracheae, and perhaps also the cells of the (medullary) rays, receive the essential breath from the tracheae. . . .

Air openings (stomata) in leaf and cortex I have searched for long and diligently, but without success.

The significance of the lenticels which he describes in the stem of the elm, is apparently not understood by Malpighi.

I can not clearly understand the meaning of respiration, unless it be that in it is liberated an active substance which serves to keep the sap in a continuous state of solution and fermentation (a condition necessary for growth). This office in animals is effected through the circulation of the blood. . . . At the same time the precipitation of the various salts present in the plant vessels is prevented. . . . Since breathing is as necessary for the plant as for the animal, the gardener works the soil around the plant roots that air may be admitted.

Nor is it only in nutrition, excretion

and respiration that analogies are sought for in the world of living things. In regard to reproduction we read that

To the animal world nature has given two sexes. One of these produces the ovum and the yolk. The other discharges a substance which may contain some active principle, which determines the growth of the embryonic parts, and as if magnetically, controls the direction of their development.

In plants, however, the case is somewhat different.

For here there is less specialization of organs, and the essential elements of the whole are present in each smallest part, so that any branch which is cut off, may give rise to a new plant. . . . As an alternative method of reproduction, nature, in the guise of seeds, may bring forth deciduous and miniature plantlets. . . . These may be regarded as pendulous and deciduous buds, capable of germination in a new ground.

The plant egg or ovum is concealed in the uterus (ovary) . . . surrounded by stamens and a floral envelope. Aeration of the egg may be facilitated by the hollowness of the tube (stigma and style) . . . and the entrance of noxious insects may be prevented by the secretion of a sticky fluid. . . . In this fluid are excreted also the impurities of the sap. The pollen dust is likewise a mere excretion, . . . prior to the maturation of the ovum, . . . and may be compared perhaps to the menstrual discharges of women. . . . The floral leaves may function in the elaboration of food for the ovum, just as do the vegetative leaves in the case of the axillary buds.

Meantime in Tübingen Camerarius is engrossed in the problem of the sex of plants.

In the almond as the uterus (ovary) increases in size, the perforated tube (stigma and style) gradually withers. . . . Within the uterus are at most two ovules (complete with integument and nucellus) in the center of which lies the embryo sac. . . . Growth in the ovule is accompanied by a hardening of the fruit wall. Within the ovule Malpighi now discerns amnion and umbilical cord. The former as we describe it to-day is apparently the beginning of embryo and endosperm, while the latter, a slender thread, is what remains of the embryo sac.[2] Soon the embryo becomes a distinct plantlet with two cotyledons, and grows at the expense of the amnion and the now developed chorion (endosperm and nucellus probably).[3] Food is conveyed to the plantlet for a time through the umbilical cord. In certain ovules, however, this is absent, or temporary only in appearance, and in these cases food is transferred from chorion to amnion and thence to the embryo cotyledons and thereafter to the developing shoot.

"But the development of the plantlet from the ovum seems still to be one of nature's secrets." And Camerarius's contribution to the knowledge of this question only appears after Malpighi's death in 1694.

Notwithstanding the somewhat far-flung analogies of Malpighi in regard to seed development, in his experimental work on the germination and subsequent growth of the seed, his feet remain, for the most part, firmly fixed on the ground. His experiments with varying culture solutions, many of them drastic in content, are less illuminating.

In animal physiology at this time, as has been already said, interest centers chiefly around circulation and the consequent nutrition of the body. That Malpighi, in his consideration of the physiology of the plant, should follow along a similar line, appears therefore to be perfectly logical. Circulation, nutrition, excretion, respiration and reproduction are functions closely interrelated, answers to some of the riddles of which may be sought perhaps in the development of the seedling.

The seeds of various plants, including Lupin, broad bean, castor bean, radish and many others, are planted in a suitable soil, watered and tended and observed with the utmost care from day to day. The function of cotyledons in the plantlet's economy is to Malpighi the mainspring of the problem of growth. He therefore amputates one or more cotyledons at earlier and later stages of seed-

[2, 3] Marcellus Malpighi, "Die Anatomie der Pflanzen." I und II Theil. 1675 und 1673, bearbeitet von M. Mobius. (Ostwald's Klassiker der exakten Wissenschaften, Nr. 120).

ling development and notes the results. The loss of both cotyledons immediately brings about the death of the seedling. If one cotyledon is allowed to remain, the young plant may slowly achieve a stunted and unhealthy growth. From these early experiments Malpighi concludes that the seminal leaves of the seedling are necessary for the early nutrition of the plant.

Water as a substance is inert, but in the soil it dissolves certain salts, similar to those found in the plant, . . . and acts as a vehicle for them. The water then which enters the seminal leaves (from the roots) is not simple and pure, but contains salts both volatile and nitrous. . . . A hardened sap lies stagnant in the seminal leaves . . . aqueous particles now enter, and with the salts they bring . . . yield a mixture which becomes the sap proper for the development of seedling and root.

This point of view runs counter to the opinions of Malpighi's former colleague, Borelli, and also to those of Triumphettus, a most persistent, if not always a particularly astute, critic. Malpighi at once sets about to defend, and by further experiment, to reconfirm his theory. Borelli, relying on animal analogy, objects to the whole idea of food elaboration. Since plants have no means of excreting waste, he maintains that they must absorb their nourishment pure and perfectly prepared for their use. Triumphettus points out that the wounding and the consequent escape of sap may be the cause of the unsuccessful growth of mutilated seedlings, and mentions further the interesting fact that, if the wounds are sealed with wax or were covered with earth, the experimental plants will succeed perfectly.

Malpighi is not entirely convinced.

I confess that after reading this (Triumphettus' letter) I was for long in serious doubt until, when the opportunity came along, I repeated the experiments, with the wax sealing used by Triumphettus; then I became certain that he was mistaken, and that the seminal leaves are really necessary to the seedling's growth.

So we find that in the early spring of 1685 Malpighi makes a long series of careful experiments. These he repeats and more fully in 1687, keeping a daily record of the plant's growth. Thus of the castor bean, we read:

After the fifth day the seedling was longer and larger, and the decaying cortex (seed coat) was still sticking to the seedling. The root was already thicker, . . . and beyond the root hair zone were seen the beginnings of secondary roots. . . . The plantlet within was developing thicker and wider leaves, yellowish in color, in which the veins were distinct. . . . The plantlet could easily be separated from the placenta (endosperm). . . . After the eighth day the leaves, now a thumb's breadth wide, have unfolded, and are green in color. . . . Between these lies the bud, made up of compact foliage leaves. . . . and so through the month growth continued, the number of nodes increasing. . . .

The results obtained once more confirm Malpighi in his theory of the function of the cotyledons.

Plant nutrition, then, in its widest sense, depending on an understanding of plant anatomy, and on experimentation, is the main theme of Malpighi's work. But the controversy of the day does not by any means run along in a single channel. The question of the fixity of species is raised by Triumphettus, who maintains that wheat of its own accord has been known to change into tares. Malpighi is unable himself to observe such a metamorphosis but indicates the range of possible variation within a single species, from his observations of the behavior of plants in cultivation and also of certain monstrosities presumably caused by disease.

That all plants arise from preexisting seeds Malpighi firmly believes, but many people are of the opinion that the earth from its own substance can bring forth living things. So we find Malpighi proving by experiment, to his own entire satisfaction, that this theory of spontaneous generation is an unsubstantial myth. No living plant is produced from soil

alone, soil taken from a distance below the surface, enclosed and protected from wind-blown seeds in a covered glass vial, even when this earth is watered and kept at a suitable temperature.

Some who delight in the theory of preformation are courteously advised by Malpighi to turn to the microscope, and with an open and unbiased mind to devote themselves to a study of the tissues of the embryo plant. Is not the human embryo in its earliest stages, though seen to be utterly devoid of bone and muscle and many other parts, nevertheless the essence of man?

And all this work on plants is the hobby of a doctor of medicine, of one who, in research along his own professional line, has made some of the most far-reaching discoveries in the history of physiology.

> The work of a man unaccustomed to the study of botany, as he modestly remarks in his all too brief autobiography, a man distracted by other work, whose peace was broken by the more serious charge of attending the sick . . . a work undertaken not that it might throw open new fields of learning . . . but that it might serve to soothe the weariness of a physician's life.

That it is, however, of importance to science as a whole, Malpighi does not for a moment doubt. In his latest writings we find him descending heavily on those practical medical men who scoff at the folly of a non-utilitarian research. "Does then medicine in its theory and practice owe nothing at all to the world of plants?"

There are many points in Malpighi's scheme of things and in that of his English compeer and contemporary, Nehemiah Grew, which the veriest tyro in a school of botany to-day can glibly criticize and summarily refute. But this fact in nowise lessens the greatness of Malpighi's work. The cycle of absorption, food elaboration and excretion remains a cycle, and respiration is still a necessity of life. Meantime the essentials of plant reproduction have emerged somewhat from the void of the unknown. Between animal and plant there is still a fundamental likeness, for the "diaphanous sap of the thin-walled utricles," is the parent of the living protoplasm, and we are looking, from a distance of three hundred years, not at a filigree of exquisite detail but at the vivid and fearless lines of an artist's earliest sketch.

CONSTANTINE RAFINESQUE

By EARL L. W. HECK

"TIME renders justice to all at last." These were the last words of "one of the strangest figures that has ever appeared in the annals of science," as David Starr Jordan once said. They were the words of an optimist; one of those who never acknowledge defeat, though for many years his name was buried in oblivion. He uttered these last words in 1840, but it was not until fifty years later that the truth of his prophecy seemed apparent.

It is rare that a great scholar and an ardent pioneer are united together in one person. When the qualities of two such admirable individualities are so combined in the same, no less than a remarkable personage can be expected to result, even though that result be of somewhat negative nature. Such was the case of Constantine Smaltz Rafinesque, "an extraordinary man, with a quaint name and with most unusual parentage." His father was Franko-Turkish; his mother, a Miss Smaltz, was Greco-German; the son, born on the shores of the Bosphorus, became an American professor in the oldest college in the then western wilderness. His father was a French merchant, engaging in business in Constantinople, in which city the son was born and after which he presumably was named.

Young Constantine did not, however, live long in the city of his birth, but during infancy returned to the city of his forefathers, Marseilles. His father must have been a man of considerable property, for we find Rafinesque saying in one of his publications that "he first became conscious of his existence in one of the summer places around Marseilles." Here he was educated, perhaps informally, as he later writes, "It was here among the flowers and fruits that I began to enjoy life, and I became a botanist. Afterwards the first book that I received in school was a book on animals, and I became a zoologist and a naturalist." He undoubtedly was a highly precocious child and the reason for his early downfall may be attributed to a too rapid development of his intellectual powers. Rafinesque's later love of travel came naturally to him, as his family seems constantly to be on the move at frequent intervals between Marseilles and the Mediterranean ports. Thus young Rafinesque delightfully spent his boyhood. At the age of eleven he had started an herbarium. At an early age he read books of Latin and Greek and at times the more entertaining "Narratives of Captain Cook." "I never was in a regular college," he writes, "nor lost my time on dead languages, but I spent it in reading alone, and by reading ten times more than is taught in schools. I have undertaken to read the Latin and Greek, as well as Hebrew, Sanskrit and Chinese and fifty other languages, as I felt the need or inclination to study them." This is Rafinesque in brief; a man a century ahead of his time; yet a trace of the Middle Ages lingers in his strange scholasticism.

But the delightful life between the pleasant gardens of an old French chateau and Mediterranean cruises to well-nigh enchanted isles was not to last forever. France was at war with George III.'s powerful navy and the British cruisers did not make it profitable for the elder Rafinesque's ships. As a consequence, the family came to America—to Philadelphia. That was a year or so

before the great epidemic of yellow fever in 1793. The father perished in that great pestilence, and the family was left friendless in a new country. The estate was settled and after all the debts were paid, the family was left in straitened circumstances.

Rafinesque had early learned to like travel. With travel he associated being a merchant. But to be a merchant, as Rafinesque conceived it, required capital and that he did not have, so he decided not to be a merchant.

Soon after his father's death he made the acquaintance of the great Dr. Benjamin Rush, of Philadelphia, who revived his interest in natural history. The two found each other's company congenial. But in 1803 Philadelphia was again ravaged by the yellow fever and Dr. Rush returns to his patients, and Rafinesque departs for the open spaces. The next year or two he spends his time tramping over the hillsides of Pennsylvania and Maryland, collecting flowers, rocks and fossil specimens. Returning to Philadelphia he meets two families destined to play a part in his later life—the Cliffords and the Tarascon brothers, Marseilles merchants, who later settle at Louisville, Kentucky. During the winter he held a clerkship in a mercantile firm, but in 1804 he resigns that post in favor of a younger brother and becomes secretary to a Mr. Gernon. But the call of distant lands and hopes of finding new plants were too strong for Rafinesque and in 1805 he sets sail for Sicily, accompanied by his brother, whom he says in his journal "would follow." This brings out another strange but important characteristic in Rafinesque's personality. His brother apparently meant little to him, although this brother seemed devoted to him. Rafinesque seldom mentions him thereafter. Plants and animals he was interested in and not brothers.

At the age of twenty-two he enters Sicily. There is something of the poet and more of the human being when he speaks of the Sicilian mountain splendor. "The mountains were smiling with flowers and verdue; they invited me to climb over them."

It was here in Sicily that the young naturalist did his best scientific work; but his energetic enthusiasm was counterbalanced by his careless methods of work. He was explosive and he got results. But alas too often were his results hastily and inaccurately drawn.

Various accounts differ as to Rafinesque and marriage. Professor David Starr Jordan, in an article published in the *Popular Science Monthly* for 1885, says that he can find no record of any woman, save his mother and sister, as being connected with Rafinesque's life. Call, however, states that in his will Rafinesque writes: "While residing in Sicily I deemed myself lawfully married . . . although the decrees of the Council of Trent forbade our regular marriage." Two children, it appears, were born of this union, a daughter in 1811 and a son in 1814. The son died the following year and the daughter is never mentioned thereafter except in the will. Whether Rafinesque eventually abandoned his wife and child altogether we can not say, but it is probable they would never consent to share his subsequent wanderings. The flowers of the field and the fishes of the waters again called Rafinesque and he leaves his lovemaking forever to return to the life he prefers. But if Rafinesque errs one way it seems his wife errs in another, because it is reported she marries again when she hears of her husband's shipwreck. In his will he definitely states that in order to inherit his small property his daughter must separate from her mother. This is all we know about Rafinesque's domestic life, and it is perhaps just as well that we know no more.

Rafinesque was somewhat successful

financially in Sicily; "by trading in the products of the island, I made my personal fortune." But he spent the greater part of his ten years in Sicily collecting botanical and zoological specimens, and the extent of his collections must have been enormous. In 1815 the wild shores of America again enticed Rafinesque to them; this time to stay. But it was with ill omens that he entered, cold, penniless and almost clotheless at New London, after suffering shipwreck at the entrance to New York harbor. This disaster had a strange effect on Rafinesque. We might judge from his earlier life that he would have considered this event as of no consequence. If he would have lost only his money and clothes it would have been different. But his collection of natural history of twenty years' labor had gone down with the ill-fated steamer. Things that he had gathered when a boy at Marseilles were among them and things he valued most. Nor did he have the friends who gave him sufficient sympathy. He grew vindictive and asocial. Fortunately at this time his friend Clifford came to his aid and encouraged him to begin another collection. Furthermore, he procured for him the post of professor of botany and natural history at the New Transylvania University, then on the edge of the western wilderness. This was the first chair of natural history to be established west of the Alleghenies, and not many had preceded it in the east. In this capacity Rafinesque made Transylvania what to-day we would call famous. Then it appeared to have been infamous. The chair of natural history was new and unclassical and looked down upon. The professor was eccentric, at times unkempt and was regarded as on the verge of insanity. The dignity of neither the chair nor the professor could much elevate the other but, like barnacles to each other, they dragged each other well-nigh to destruction. Rafinesque held on for six years and while at Lexington wrote the crowning piece of his life, "Ichthylogia Ohiensis," published in that city in 1820. It made the author famous if not rich and at the time was a member of half a dozen of the leading learned societies of the world. Now "Ichthylogia" is one of the rarest bits of middle-western Americana.

When the break between Rafinesque and Transylvania came he left, loading the college with curses, and he took himself at once to the hillsides of Kentucky, undoubtedly glad that he was a professor no longer, but a joyful vagabond.

He continued to investigate and to publish as long as he had the money, but all the while sinking deeper and deeper into oblivion. When he died in 1840 he left an elaborate will but little else. At least he died like a gentleman with all his affairs settled properly. Only for the interference of a few old friends was his body saved from a medical college. Now his bones are said to rest in the campus of Transylvania which in older days drove him forth and which in turn he cursed.

Rafinesque was a genius in the best sense of the word; inasmuch as he saw light where others failed to see even darkness. He had learned to solve the problem of material existence and to sacrifice sensual pleasures for those mental and spiritual. He was a pioneer both in spirit and habitation. There is little doubt that he preferred the wild wilderness of the lower Ohio Valley to the refinement of Philadelphia or the gay pleasures of Paris and Marseilles; yet he was equally at home in both, or at least he never felt himself out of place in the latter, although many may have thought so, shallowly judging from his queer dress.

But as a genius, Rafinesque lacked those qualities of the common man which go toward recognition and worldly suc-

cess. He delighted in flowers and went into ecstacies when Audubon showed him a new plant. "Not only a new plant but a new genus, Mr. Audubon," he exclaimed, embracing the great ornithologist. Then the task of describing the new genus! That is where Rafinesque failed. Not that he did not fully understand this new genus nor that even his description was unintelligible to himself later. But his love of introducing novelties and fancy clouded for other scientists what to him was ever clear. But then perhaps only another genius could understand his point of view. Darwin, I believe, did, although there is no record that he was acquainted with Rafinesque's work; but the ideal science Darwin had in mind when he said, "What a joyful life a scientist would lead if he could ever observe and never write," approached very closely the science of Rafinesque. Perhaps Darwin had something more of the common man when he considered it his duty to write his notes carefully for other people to read later. But not so with Rafinesque. Little did he care who read his notes, for he made them for himself. One of the most remarkable instances which clearly shows this utter indifference to the world was in 1820 when he edited a scientific periodical called "Annals of Nature." From the first he was editor and sole contributor; ere long he became sole subscriber, which did not in the least affect the status of Rafinesque's periodical. When, however, he could no longer afford to pay the price of subscription, "Annals of Nature" ceased publication; but it was a case of necessity rather than expediency.

Rafinesque remained a child and from his child-like simplicity came his boundless supply of enthusiasm. How gloriously naive when, as professor of botany and natural history lately exiled from Transylvania, he exclaims with unfeigned vehemence, "I took lodging in town and carried there all my effects, leaving the college with curses both on it and [President] Holly, which reached them both soon after; for Holly died of the yellow fever in New Orleans and the college was burned with all its contents." And undoubtedly Rafinesque, eminent scientist as he was, died with the belief that this malediction was the cause of Transylvania's downfall. Who other than an unspoiled child would have the grace to pull off his shoes and cover up the holes in the heels with the sock part of the stockings before a group of strangers and do it all without embarrassment but actually with charm. But this is what Rafinesque did, the first time in Audubon's house, and before the whole family. "He told us in the gayest mood imaginable that he had walked a great distance . . . and was sorry his apparel had suffered so much from his late journey."

On the other hand, there are times when he displays those qualities which in children we call "pouting" when the individual is out of sorts with the world for little or no reason. "Some hearts of stones," he writes after his shipwreck, "have since dared to doubt of these facts or rejoice at my losses. Yes, I have found men vile enough to laugh without shame at my misfortune instead of condoling with me!" But he is fair with himself when he admits, "There were also friends who helped me in my distress."

Peculiarly enough the shipwreck did leave a visible mark on Rafinesque's later life. What an ordinary man would soon forget or at least learn to look back upon the event not without humor, Rafinesque took to heart and bewailed his loss for years to come. Although only thirty-two years old, he thought he was too old to begin again, and his scientific writings from that time on showed a steady decline, to rise for only once in his "Ichthylogia."

It is either very comical or very pathetic when Rafinesque describes in a scientific paper a series of most unusual fishes which are said to inhabit the lower Ohio River and painted by Audubon; and the illustrations given to Rafinesque and described as real by Audubon in retaliation for the destruction of the latter's favorite violin on the part of Rafinesque, who used it for killing bats once while visiting the great ornithologist at Henderson.

It would speak well for Rafinesque if his friends could prove this joke played by him on other naturalists. But there is very little reason to believe this is so. When we remember his love for introducing the unusual, it seems we must admit this to have been done in all scientific seriousness.

Rafinesque was not an Agassiz because he had not that fine discriminating eye and mind. But Agassiz thought well of Rafinesque and spoke well of his work, and adopted many of his classifications. Perhaps Agassiz would not have been the great naturalist which he was had it not been that Rafinesque had partially paved the way. If there ever was a scientist "crying in the wilderness" Rafinesque was that man.

But there is another reason why Agassiz has ever been at the acme of scientific reputation and Rafinesque at the lowest. All Europe and America mourned when Agassiz died, but Rafinesque died obscure and poor. But what a difference between the two men. Agassiz loved the men and women of the world and in turn they loved him; Rafinesque lived for himself, alone, lovingless and unloved. Agassiz was a great personality; Rafinesque a great mind, the mind of a genius, perhaps, but still only a mind.

TWO-HEADED SNAKES

By BERT CUNNINGHAM
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The two-headed specimen of the spreading adder which initiated this study came into my possession in an unusual manner. It was discovered by men who were making a run of illicit liquor when the small reptile came up to the fire either from curiosity or to warm itself. The men, fearing that their senses were fooling them, captured and preserved the reptile in their brew in order that they might observe it under more favorable conditions. The specimen was lost to science when it had to be returned to its owner to settle a bet. The route by which the specimen came to me was so indirect that I have been unable to trace the original ownership.

However, good use was made of the specimen while in our possession. Photographs were made of the external appearance and X-rays were made of the skeleton. These are shown in the accompanying figures. (See Fig. 1 and Fig. 2.)

Through the kindness of Dr. E. W. Gudger, of the American Museum, and Mr. C. S. Brimley, of Raleigh, N. C., some references to the literature of the subject were secured. With these as a basis, the writer has been able to secure a rather extended bibliography. Although the many references to this phenomenon are scattered, there have been two rather exhaustive papers published upon this condition—the first by Johnson in the *Transactions* of the Wisconsin Academy in 1901, and the other by Strohl, which was published in 1925 in the *Annales des Sciences Naturalles Zoologie*. Both of these articles carry good bibliographies which are remarkably supplemental.

Animals possessing two heads have been described in two ways. Among these there are those which are reputed to have a head on each end of the body, and there are those having multiple heads on the anterior end of the body.

Among the first are the snake-like lizards, that is, lizards without legs, to which belongs the genus *Amphisbaena*. (See Fig. 3.) These animals are nearly the same diameter throughout their entire length. When disturbed, they have the peculiar habit of elevating the tail in much the same manner that a snake does its head. Ditmars in describing the animal says, "The tail is just as thick and stumpy as the head; unless one examines the animal closely, the two extremities can not be told apart," and further, "When a specimen was annoyed it would elevate the stubby tail in a fashion that caused the organ to look like a head reared in threat; at such times the head remained flat upon the ground unless the body was pinched: then the head swung about for the offender." They are also reported to have the habit of running backward with the same agility as they go forward. Hence the name. With these two habits combined, one is not surprised to find that some observers thought the animals possessed of two heads. There is also a group of snakes having somewhat similar characteristics, the *Eryx johnii*. The Hindoos painted a mouth and eyes on the blunt end to make the appearance of two-headedness more conclusive.

The *Amphisbaenas* (the snake-like lizards) were considered as extremely poisonous according to Bancroft. This writer pointed out the improbability of the *Amphisbaena* having two heads since "there is no animal in nature that is thought to have two heads." In a footnote to this sentence he reports and figures a genuine dicephalous case (see Fig. 6) occurring in a specimen from the Lake Champlain region, which he designated as an *Amphisbaena*. This animal is in no wise similar to *Amphisbaena*, but is rather to be grouped with those having anomalies of development which are now to be considered.

Of the snakes having the dicephalous anomaly, there have been from twenty to thirty cases reported, ranging from those having skulls but slightly separated to those having necks of considerable length. (See Figs. 4 and 5.) In some the ribs from one vertebra fuse with those of the vertebra lying opposite. This may be observed in our specimen (see Fig. 2) as well as in *Pityophis sayi* (see Fig. 4). It can also be seen that in our specimen the bifurcation begins with a Y-shaped vertebra.

The internal anatomy of some of the specimens has been studied. In all cases it is to be supposed that the alimentary canal is double for some distance, although we did not demonstrate this in our specimen. Both mouths are reported as functional, and it has been observed that when one mouth has eaten, the other ceases to be hungry. However, both heads will attempt to swallow the same morsel. In a case reported by Lessona, there were two sets of lungs present, although three of the four were atrophied; there were also two livers, one of which was larger than the other; the heart also was paired.

Although most of the specimens reported were small and presumably young, some virtually newly born, Lessona cites Redi as having had in his possession an adult snake having two heads.

Since nature does not often produce such monsters, it is legitimate to ask why does she produce any. It is comparatively easy to understand why placental animals become twin monsters, and the spina bifidal effects of pressure on frog eggs, but what can happen to a hen's egg that would make it produce a four-legged, three-winged monster is a mystery. The same might be said with a reasonable degree of assurance about the snake egg.

One of the more common explanations is that the phenomenon is due to a double yolk. Double yolks may be responsible, but I have seen two turtle embryos (*Chrysemys marginata*) on a single embryonic disk. They were small, about 4 mm., but apparently perfect. It would not take much imagination to see them fuse into a two-headed monster with a single body.

Another explanation is that the condition is due to pressure. Pressure effects would in all probability depend upon the rigidity of the shell. Certainly in chicks this would not be the cause, for it has been shown that chick embryos produced under increased atmospheric pressure show no more anomalies than those produced under normal pressure. In such animals as *Chrysemys marginata* where the shell is flexible the turgidity is so great that considerable external pressure would be required to produce any effect.

The possibility of two germ nuclei in a single embryonic disk, or the separation of the blastomeres produced in first cleavage with independent development for a time and later a partial fusion, seems more reasonable, although neither of these explanations is wholly satisfactory.

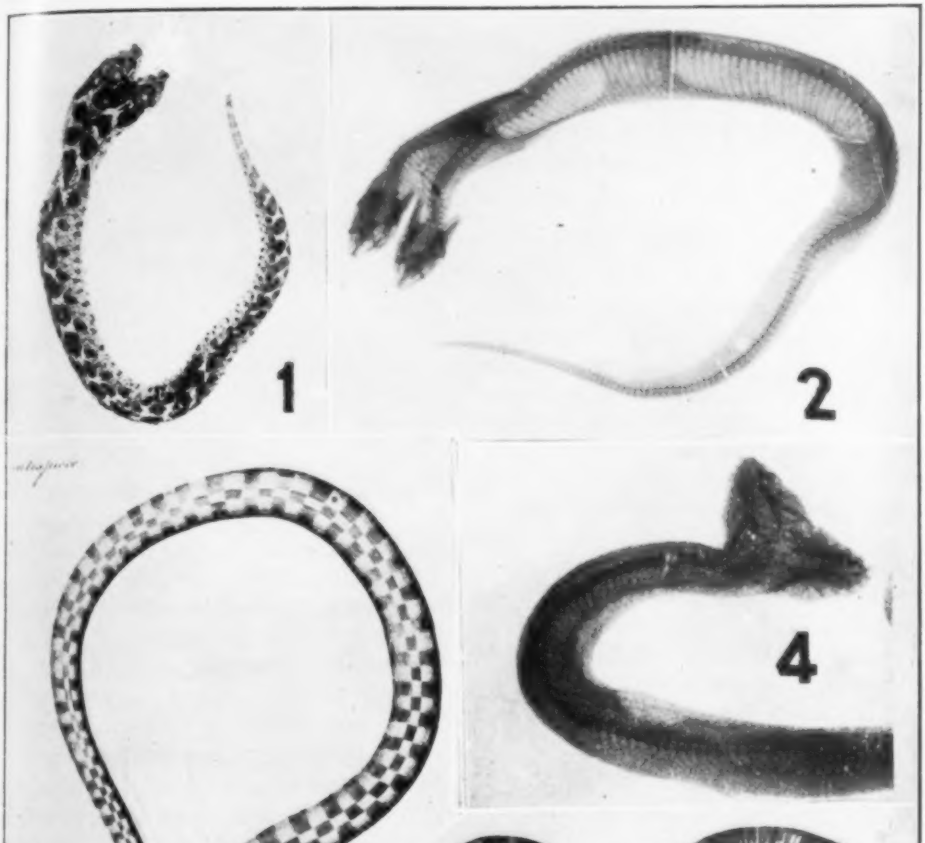

Fig. 1. Original photograph of a dicephalous specimen of spreading adder. Fig. 2. Original X-ray photograph of same specimen. Natural size. Fig. 3. Photograph of Amphisbaena alba as figured in "Synopsis der Drei Naturreiche," Lennis. Fig. 4. Photographic copy of dicephalic figure in "Axial Bifurcation of Snakes," by Johnson. Fig. 5. Photographic copy of another case cited by Johnson. Fig. 6. Photographic copy of the "Amphisbaena" figured by Bancroft. Figures 4 and 5 illustrate the wide differences in bifurcation.

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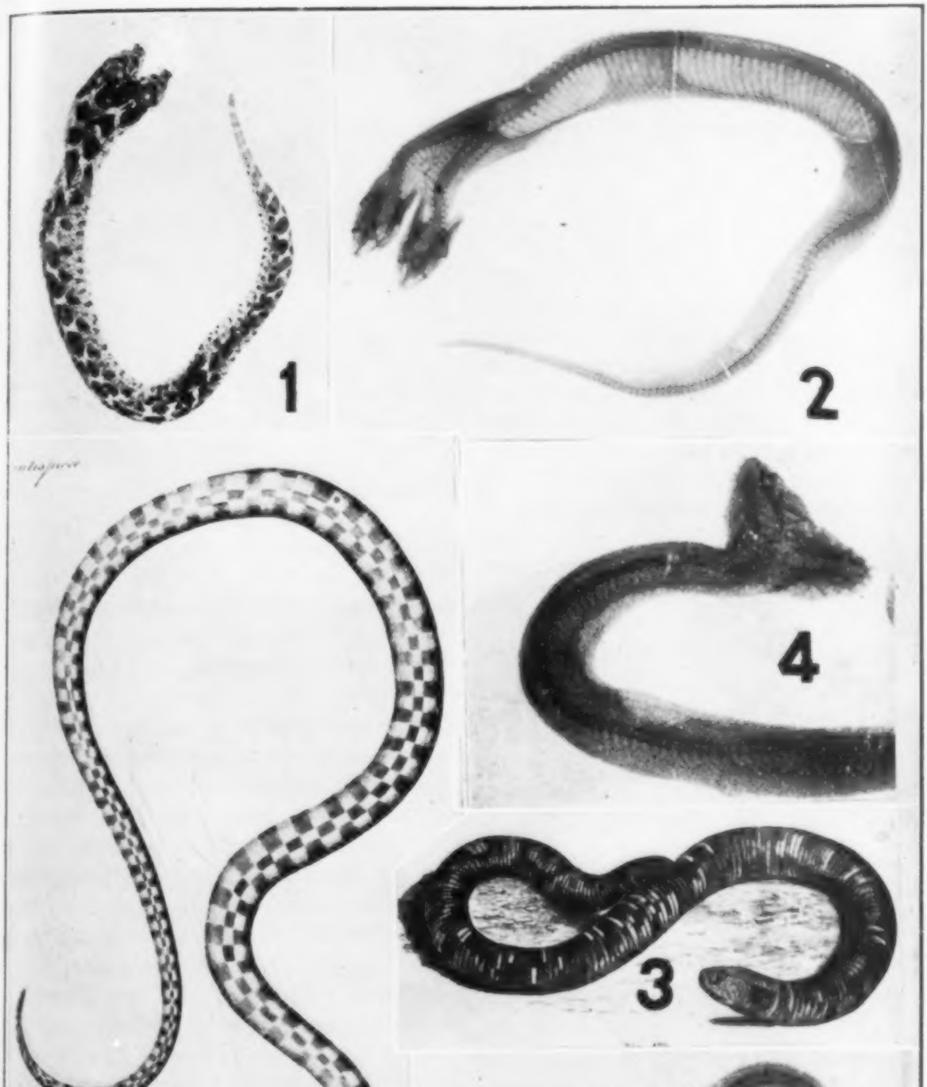

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A TWIN TURTLE

By Professor S. HOFFMAN DERICKSON

LEBANON VALLEY COLLEGE

EXAMPLES of twinning with various degrees of union of the two individuals is fairly common among the vertebrates, although more frequent in some classes than in others. They are not so common, however, as to pass unnoticed.

One of my students, Mr. V. Earl Light,[1] brought in for my inspection a twin painted turtle, *Chrysemys picta*, which he had borrowed from a neighbor. The specimen had been found several years before by the neighbor's little daughter near an abandoned canal a few miles west of Harpers, Lebanon County, Pa., in the early summer. The child was attracted by its peculiar appearance and ungainly ways and took it home. Her mother put it in a jar on the back porch of the farm house, where it lived in spite of lack of proper food and the heat of the afternoon sun beating in on it for about three months. It was the curiosity of the neighborhood but failed to fall under the attention of any one inclined to make a critical study of its behavior and give it proper care and attention. Accordingly, one hot afternoon in August it died, probably from a "complication of conditions."

Some months ago I visited the family in company with Mr. Light and from their recollections we gleaned the following concerning its behavior: It could swim and handle itself in the water very well. It was given various kinds of food, bread, meat, vegetables, fruits, etc., but was never seen eating, although they supposed that it ate some of the food placed in its jar. When placed on the ground its movements were more awkward. Sometimes the movements of the front feet seemed to be coordinated, but usually they appeared to act independently and with contrary movements. Likewise, the heads sometimes agreed but more frequently disagreed. It is indeed unfortunate that it did not fall into the hands of some one who would have kept it under observation in conditions where it might have lived and provided an interesting record of its behavior.

The accompanying photographs made by the author show most of the peculiarities of its external structure. The radiograph, rather indistinct on account of the youth of the specimen and the manner in which it was preserved, reveals a few facts concerning internal structures. Permission could not be obtained from the owners to dissect and examine the internal structures, as they hope to obtain a fabulous price for the specimen, which we found had been preserved in vinegar and salt in a pint jam jar.

The extent of fusion, or separation, whichever the case may be, affected the different regions of the organism quite differently. The anterior, including the head and neck, consists of two almost perfect duplicates. The dorsal region consists of two carapaces not quite complete. The adjacent margins of the two are bent dorsally and form a prominent median ridge seen in Fig. 1. The marginal plates of the two are fused at the top of this ridge. The base of the ridge consists of the right and left costal

[1] Light, V. Earl, "A Double Turtle of the Genus Chrysemys." Proceedings Pennsylvania Academy of Science, Vol. 1, 1925.

Fig. 1. Anterior view of a twin turtle, Chrysemys picta.

plates of the two individuals with their ventral surfaces in contact and fused. The ridge does not extend to the posterior margin but ends in front of a plate which resembles a normal neural plate in form and position, although each carapace contains the usual five neural plates in addition to the plate in question, which is apparently an extra neural. Mr. Light interpreted this as an extra costal plate. Posterior to this extra neural plate the twelve marginal plates of the left side of the left carapace are separated from the twelve marginal plates of the right side of the right carapace by the usual pygal plate, below which the single tail protrudes. The posterior aspect resembles that of a single normal individual. The fused margins each present eleven marginal plates, the eleventh pair form the posterior limit of the ridge referred to in a preceding paragraph and are immediately in front of the extra neural plate, which therefore takes the place of the twelfth pair of marginal plates and may be formed by the fusion of the elements which should have normally produced marginal plates, as is indicated by their color markings. The coloration in general is typical of that of the species; there are, however, a few exceptions which are of interest. The fused marginal plates which form the ridge previously referred to are without the usual red spots. The nuchal plates, normally without red markings, here are spotted with red-like marginal plates. Both of these color differences may be interpreted as indicating that color development is influenced by the general symmetry of the organism as a whole rather than by the development of a specific morphological unit.

Two other abnormalities appear on the epidermal plates of the dorsal side. The fifth neural plate on the right carapace is reduced in size and triangular in shape, due to the protrusion of the posterio-lateral angle of the neural plate in front of it. An extra costal plate appears on the left side of the left carapace posterior to the usual four which it resembles in form but is much reduced in size.

The median elevation extending from nuchal plate to pygal plate on a normal turtle is evident on both carapaces, as

Fig. 2. Dorsal aspect of a twin turtle.

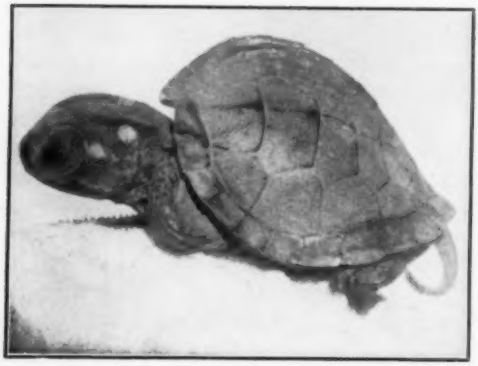


FIG. 3. LATERAL VIEW OF TWIN TURTLE.

may be seen in Figs. 1 and 3, but are not as prominent as on the normal specimen.

The ventral portion of the body seen in Fig. 4 shows little evidence of twinning. A small triangular plate is wedged in between the two gular plates, slightly increasing the width of the anterior end of the plastron.

A mid-ventral scar, possibly indicating an abnormal yolk sac withdrawal, is seen extending posteriorly.

FIG. 4. VENTRAL VIEW OF TWIN TURTLE.

The endoskeleton shows more extensive twinning in the interior of the body, as is shown in the radiographs in Fig. 5.

There are two vertebral columns back to the sacrum and a single column continued into the tail. The pectoral girdle appears to be formed in duplicate also, although the adjacent parts, if present, are greatly reduced. If the adjacent front legs are represented at all, they are so greatly reduced, or lacking in ossification, that they failed to register on the radiograph. Radiographs were taken from a number of additional angles but reveal very little in addition to what is registered on the dorsal and ventral views herewith presented in Fig. 5.

FIG. 5. RADIOGRAPHS OF TWIN TURTLE.

We have not been able to make an exhaustive study of the literature on this subject, but through the kindness of Dr. E. W. Gudger, of the American Museum of Natural History, have been able to compare the specimen with the

description and figures of two somewhat similar specimens.

Barbour[2,3] has described a young tortoise of the same species which resembles the subject of this paper in several particulars. His specimen also had two heads and necks, as shown in his figures, which are herewith reproduced. His

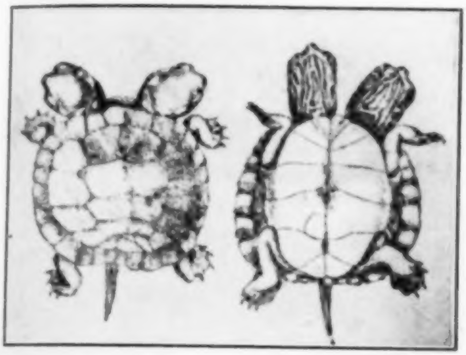


FIG. 6. DORSAL AND VENTRAL VIEW OF TWO-HEADED TORTOISE, CHRYSEMYS PICTA, AFTER BARBOUR.

specimen was a trifle broader than long. The specimen we describe is one twelfth longer than broad. His specimen had two extra gullar plates, as against one in this specimen. His specimen had a single carapace, as compared to the two almost complete carapaces of this specimen. His specimen had one nuchal and two pygal plates in contrast to the two nuchal and one pygal of this specimen. The fifth neural plate is abnormal on both. His specimen also had a mid-ventral scar but not as prominent as on this one.

The external evidence of twinning is carried much farther on this specimen than on Barbour's.

Barbour's account includes a very interesting series of observations on the behavior of his specimen from soon after hatching in June until its death, caused by a cat scratch, in September of the same year.

Bernard[4] reviewed Barbour's first article in *Cosmos* shortly after it appeared.

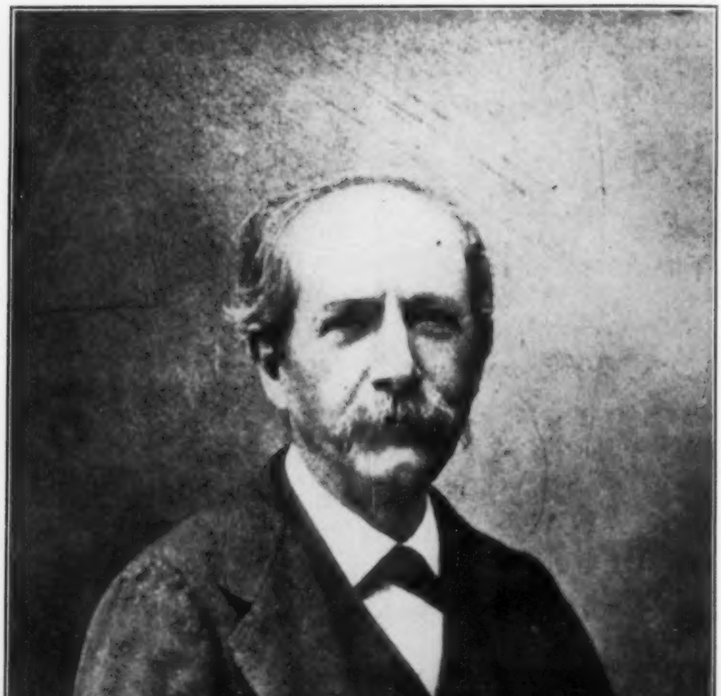
Hennig[5] gives an interesting account of the behavior of another somewhat similar specimen found in 1869.

[2] Barbour, E. H., "On a Young Tortoise, Chrysemys picta, with Two Heads," *American Journal of Science*, third series, Vol. XXXVI, No. 214, October, 1888.

[3] Barbour, E. H., "A Two-headed Tortoise," *Science*, n. s., Vol. IV, No. 84, p. 159.

[4] Bernard, S., "Une Tortue à Deux-Tetes," *Cosmos*, 200, pp. 454–455, October, 1888.

[5] Hennig, Dr. C., "Einie Zweikopfige Eidechse," *Cosmos*, revue encyclop, hebdom. des progres des sciences, (v. Mennier), Paris, 21 August und 31 Juli, 1869.



MARCELLIN PIERRE EUGENE BERTHELOT

THE PROGRESS OF SCIENCE

THE BERTHELOT CENTENARY

Marcellin Berthelot was born in Paris on October 25, 1827, and the exact centenary of his birth was celebrated in Paris by the laying of the foundation-stone of the new International House of Chemistry, to be erected as a memorial to him. Subscriptions have been received from forty nations amounting to over fifteen million francs, one half of which has been given by France. Contributions from the United States amount to about five hundred thousand francs, but the American Chemical Society has taken exception to any official support by the society or the federal government, having at its recent Detroit meeting adopted a statement to the effect that "The American Chemical Society has naught but good wishes for the 'Chemists' Club' of New York, the long considered 'House of Chemistry' of Great Britain, the 'Hofmann House' of Berlin, or for a national 'Maison de la Chimie' to be located in Paris and would be glad to see any of its members, who are so inclined, contribute to their support. It can not, however, admit the propriety of any national group assuming the right to centralization of control of international chemistry within its own territory and sphere of influence, even if the major costs of construction and upkeep of such an institution were not assessed upon the rest of the world. The American Chemical Society believes that if an International Office of Chemistry, having as its object the centralization of influence of chemical science, both pure and applied, is ever deemed desirable or necessary, it should be inspired through cooperative action of the world's scientific chemical organizations and not by governments through political channels."

The principal address at the ceremonies of the laying of the corner-stone (the site of the building has in fact not yet been chosen) was by M. Donet-Agache, president of the French Society of Chemical Industry, who is reported to have said: "The International Chemical House will be of great value to all and not, as some believe, a luxury for a certain section of intellectual workers. Its purpose is similar to that of the great Pasteur Institute and other notable schools and laboratories. It will be a true meeting ground for scientific life, where professors, scholars, business men and savants of the whole world can come together and exchange ideas. The house will place at their disposition all the resources of a great technical library, and also all available publications, as issued. It will be headquarters for those savants and foreign business men who desire to cement and continue private relations, for which the recent World Chemical Congress demonstrated the necessity as well as demonstrated their worth. It will add to our dear Paris, city of art and beauty, a world intellectual center where disciples of Berthelot can renew the sacred fire of their calling."

M. Donet-Agache concluded by explaining that in constructing the International House in Paris, France sought no chemical hegemony, even of a scientific nature, but was merely carrying out in the domain of science the dream of Berthelot.

According to the report printed in *Nature* the proceedings began with a reception at the Sorbonne on the evening of Sunday, October 23, by M. Charléty, the rector of the University of Paris. On Monday morning, in the presence of rep-

resentatives of the French Government, a museum of apparatus and manuscripts relating to Berthelot was opened at the Faculty of Pharmacy by Professor Radet; the visitors were next received at the Collège de France by M. Croizet; after speeches by the president of the German Chemical Society, Professor Schlenk, and Professor Bogert, of Columbia University, Berthelot's former laboratories and apparatus were inspected. Later, a memorial tablet was unveiled on the wall of Berthelot's early residence, 113 Rue Saint Martin, and speeches were made by M. Boujou, Préfet de la Seine.

The chief meeting was held in the large amphitheater of the Sorbonne on the evening of October 24; discourses were pronounced by Professor Ch. Moureu on the work of Berthelot, and by Professor Lacroix, secretary of the Academy of Sciences; M. Georges Lecomte, director of the Académie française; M. Gley, president of the Academy of Medicine; M. Wéry, president of the Academy of Agriculture; M. Hodza, Minister of Education for Czecho-Slovakia, and by M. Paul Painlevé. Addresses were presented on behalf of numerous academic bodies; it is indicative of the wide-spread interest in the celebration that the first addresses handed in were those from Abyssinia and Afghanistan.

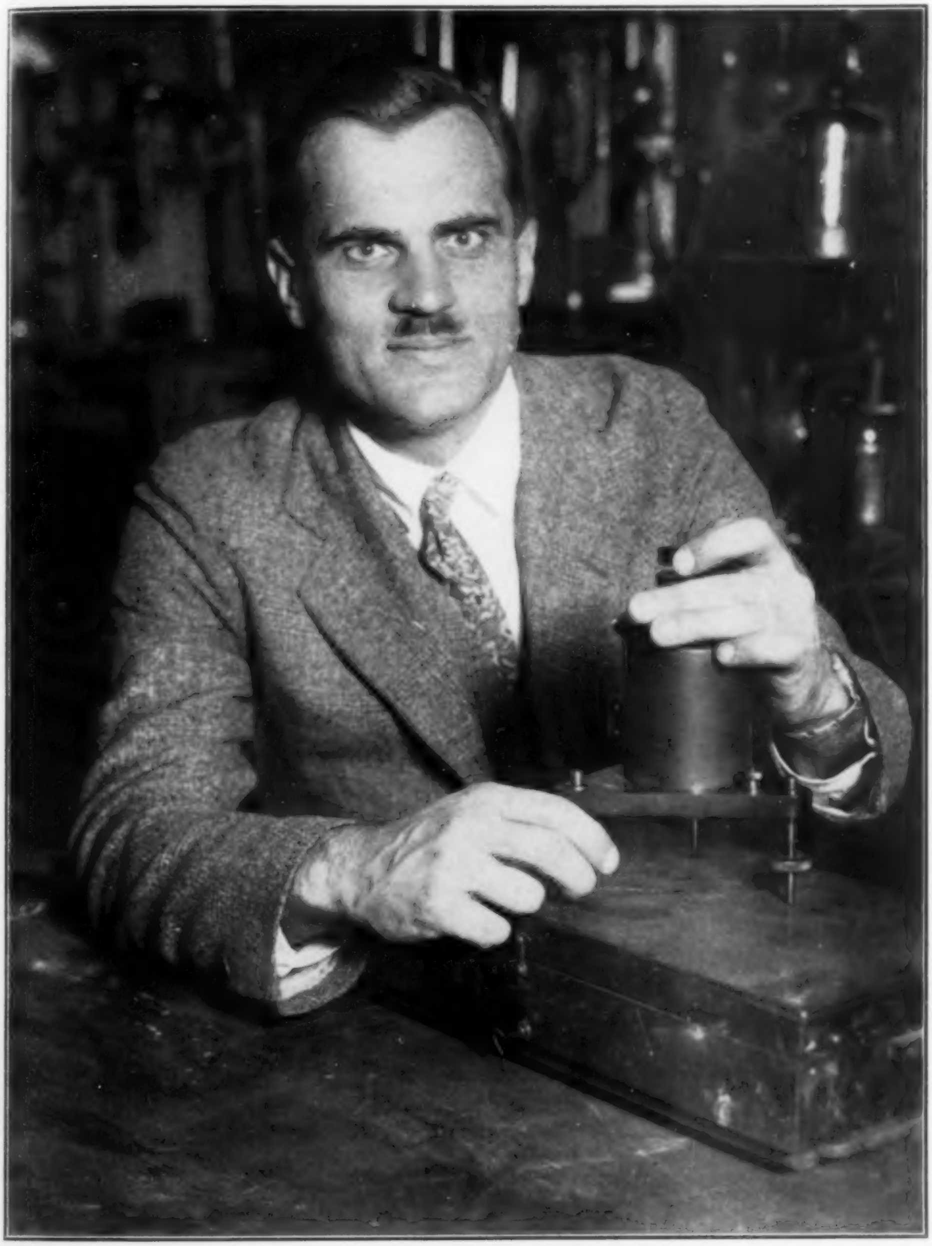
A commemoration ceremony took place at the Panthéon on Tuesday morning, October 25, when speeches were made by M. Raymond Poincaré and by M. Galliardo, minister of foreign affairs of the Argentine Republic. This was followed by a lunch in the Galérie des Batailles at Versailles, which was attended by some 1,200 guests, and discourses were delivered by M. Herriot, minister of education; Professor Amé Pictet, of the University of Geneva, and M. Lunatcharsky, minister of education to the Union of Socialist Soviet Republics.

On Wednesday morning, October 26, the foundation-stone of the new House of Chemistry was laid in the Place d'Iéna by M. Herriot; M. Donat-Agache, president of the French Society of Chemical Industry; M. Zumeta, the Venezuelan Minister, and Professor Ernst Cohen, of Utrecht, spoke, and the party adjourned for lunch to the château belonging to the French Academy at Chantilly, where discourses were pronounced by M. Lecomte, director of the French Academy, and Professor H. E. Armstrong. In the evening the delegates were received by President Gaston Doumergue at the Palais de l'Elysée. It is proposed to issue a commemorative volume giving a full account of the proceedings of the Berthelot centenary celebrations.

RADIUM AT THE MEMORIAL HOSPITAL

THROUGH the generosity of the late Dr. James Douglas, the Memorial Hospital of New York City, during the last ten years, has had in its possession four grams of radium for the treatment of cancer and allied diseases. Recently a gift of $250,000 from Mr. Edward S. Harkness has made it possible for the hospital to increase its radium supply to eight grams, which is the largest amount controlled by any institution. While the first four grams are kept in solution, to provide a constant supply of radon (radium emanation), which is then used for therapeutic purposes, the last four grams are kept in a special container which is applied directly to the patients.

Before describing this apparatus, it may be well to outline briefly how radium is used for the treatment of cancer. In the first place, it should be noted that radium is not used as a drug.



ARTHUR H. COMPTON

TO WHOM THE SWEDISH ROYAL ACADEMY OF SCIENCE HAS AWARDED THE NOBEL PRIZE IN PHYSICS IN CONJUNCTION WITH PROFESSOR CHARLES THOMPSON REES WILSON, OF THE UNIVERSITY OF CAMBRIDGE. PROFESSOR COMPTON IS HERE SHOWN WITH HIS X-RAY SPECTROMETER. THE NOBEL PRIZE IN PHYSICS HAS PREVIOUSLY BEEN AWARDED IN THE UNITED STATES TO PROFESSOR A. A. MICHELSON, OF THE UNIVERSITY OF CHICAGO, AND TO PROFESSOR ROBERT A. MILLIKAN, OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY. PROFESSOR KARL T. COMPTON, OF PRINCETON UNIVERSITY, THE BROTHER OF PROFESSOR ARTHUR H. COMPTON, IS ALSO A DISTINGUISHED PHYSICIST.

THE NEW YORK HOSPITAL AND CORNELL UNIVERSITY MEDICAL CENTER

THE ARCHITECTS' DRAWING SHOWS THE SOUTHERN FRONT OF THE PROPOSED BUILDING WHICH WILL HOUSE THE NEW YORK HOSPITAL AND THE CORNELL UNIVERSITY MEDICAL SCHOOL AND IS TO BE ERECTED AT A COST OF $11,000,000. AN ADEQUATE ENDOWMENT FUND FOR THE COMBINED INSTITUTIONS IS PLANNED, AND A SUM OF $25,000,000 IS ALREADY AVAILABLE, LARGELY FROM LEGACIES PROVIDED IN THE WILL OF THE LATE PAYNE WHITNEY AND AN APPROPRIATION OF $7,500,000 FROM THE GENERAL EDUCATION BOARD. THE NEW YORK HOSPITAL-CORNELL UNIVERSITY MEDICAL COLLEGE ASSOCIATION—AS THE COMBINED INSTITUTIONS ARE OFFICIALLY DESIGNATED—WILL OCCUPY TWO BLOCKS OF LAND IMMEDIATELY NORTH OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH. THE ARCHITECTS, MESSRS. COOLIDGE, SHEPLEY, BULFINCH AND ABBOTT, HAVE ACTED IN THE SAME CAPACITY FOR THE MEDICAL SCHOOLS OF HARVARD UNIVERSITY, VANDERBILT UNIVERSITY AND OTHER INSTITUTIONS. DR. GEORGE CANBY ROBINSON, WHO IS THE PRESENT DEAN OF THE MEDICAL SCHOOL OF VANDERBILT UNIVERSITY, WILL BE THE DIRECTOR OF THE NEW MEDICAL UNIT WHICH WILL BE READY FOR OCCUPANCY IN 1930.

—*Wide World Photos*

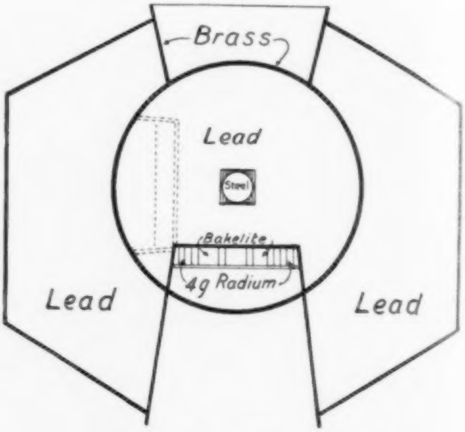
CONFERRING OF THE JOHN SCOTT MEDALS

THE PHOTOGRAPH SHOWS DR. HERBERT A. HARE, DISTINGUISHED FOR HIS WORK IN EXPERIMENTAL THERAPEUTICS, PRESENTING JOHN SCOTT MEDALS TO DR. ALFRED F. HESS, OF COLUMBIA UNIVERSITY, AND DR. AFRANO DO AMARAL, OF THE ANTIVENIN INSTITUTE OF AMERICA AT GLENOLDEN, PENNSYLVANIA. A MEDAL WAS ALSO CONFERRED ON DR. PEYTON ROUS, OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, WHOSE WORK HAS BEEN CONCERNED LARGELY WITH THE TRANSPLANTATION OF CANCEROUS CELLS IN CHICKENS. DR. HESS HAS IN RECENT YEARS BEEN ENGAGED IN THE STUDY OF ULTRA-VIOLET LIGHT, ESPECIALLY IN ITS RELATION TO RICKETS. DR. DO AMARAL, A NATIVE OF BRAZIL, HAS PLAYED AN ACTIVE PART IN THE DEVELOPMENT OF SERUMS WHICH CAN BE USED TO PREVENT DEATHS FROM SNAKE BITES. THE FUND FROM WHICH THE AWARD IS MADE WAS ESTABLISHED OVER A CENTURY AGO WHEN JOHN SCOTT, AN EDINBURGH CHEMIST, BEQUEATHED $4,000 TO THE CITY OF PHILADELPHIA. THIS WAS TO BE "LAID OUT IN PREMIUMS TO BE DISTRIBUTED AMONG INGENIOUS MEN AND WOMEN WHO MAKE USEFUL INVENTIONS." IT IS NOW AWARDED ON THE ADVICE OF A COMMITTEE CONSISTING OF REPRESENTATIVES OF THE UNIVERSITY OF PENNSYLVANIA, THE AMERICAN PHILOSOPHICAL SOCIETY AND THE NATIONAL ACADEMY OF SCIENCES.

That is, it is not administered to the patient in the form of pills, powders, solutions, salves, etc. In fact, it never comes in actual contact with the patient. Its action is due to the powerful rays which it emits constantly and spontaneously. The gamma rays, which are the ones chiefly used for the treatment of cancer, are capable of passing through opaque substances with little absorption. Therefore, radium can influence living tissues not only without actual contact, but even through a sheet of metal several millimeters thick.

Radium rays are capable of affecting all living tissues. The effect may vary from an imperceptible one to complete destruction, depending on the amount of radiation which has been absorbed by the tissue. Some tissues are more easily affected than others. Thus certain types of cancer are more susceptible to radium rays than the normal tissues surrounding the tumors, while other types are less susceptible. Remembering that the object of radium therapy is to get rid of a tumor without serious injury to the normal tissues or the patient as a whole, it will be seen that the particular method of applying the radium depends largely on the type of cancer one is dealing with and its location. Sometimes it is necessary to place the radioactive source within the tumor mass itself; sometimes surface applications are sufficient; in other cases it may be desirable to place the radium at a distance of several centimeters from the surface. The four grams of radium recently acquired by the Memorial Hospital are used exclusively for such external applications.

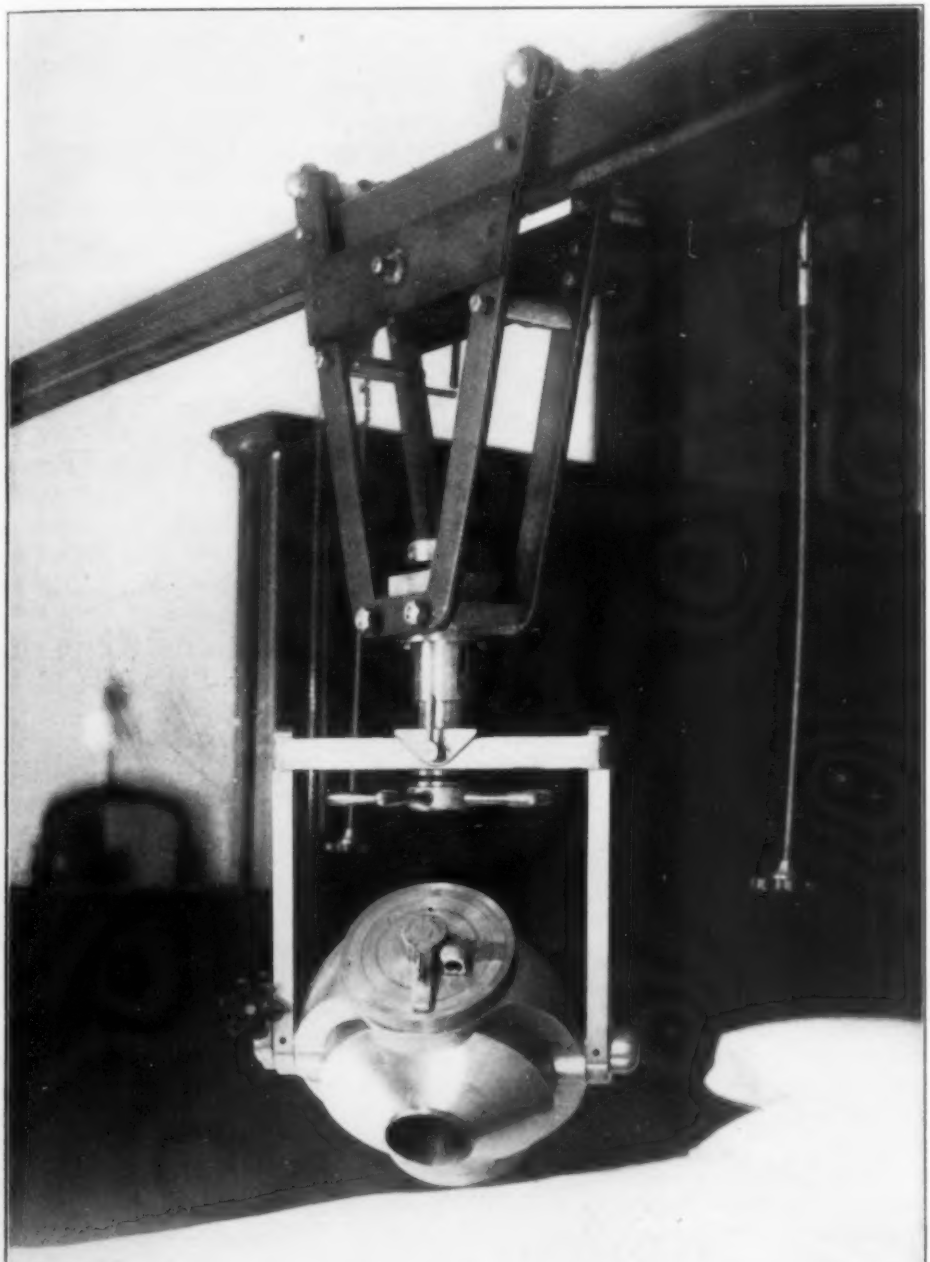
The design of a suitable container for this purpose must fulfil two essential requirements which are more or less antagonistic. That is, the container must afford sufficient protection to the operator who applies it, and at the same time must be sufficiently flexible to make possible its adjustment to any part of the patient's body. On account of the great penetrating power of gamma rays, a large mass of lead is required around the radium, and this makes it impossible to rest the container on the patient's body. The appliance used at the Memorial Hospital is suspended from a horizontal beam, which is moved up and down as a whole by an electric motor.



RADIUM CONTAINER

CROSS-SECTION OF CONTAINER USED FOR EXTERNAL APPLICATIONS. GAMMA RAYS FROM THE FOUR GRAMS OF RADIUM PASS THROUGH 0.5 MM. OF PLATINUM AND 2 MM. OF BRASS BEFORE REACHING THE PATIENT. THE AVERAGE THICKNESS OF THE LEAD PROTECTION IS 10 CM.

A cross-section of the container is shown in Figure 1, and a photograph in Figure 2. Forty platinum capsules, each containing 100 milligrams of radium, are distributed over a (bakelite) circle 7.5 cm. in diameter. This disc is inserted into a recess milled out of the side of a lead cylinder 15 cm. in diameter and 28 cm. long. The cylinder is fitted into a large lead casting of the shape shown, and is supported coaxially by a steel shaft running on ball bearings. By this arrangement it is possible to turn the cylinder so that the radium is pointed towards one or the other of the two openings provided in the lead casting; or it can be placed in the position shown by



PHOTOGRAPH OF RADIUM CONTAINER
SHOWING METHOD OF SUPPORT AND FLEXIBILITY OF ADJUSTMENT.

the dotted lines in Figure 1, in which case the radium is completely surrounded by lead. The lead cylinder weighs about 200 pounds, but it can be turned easily by a handle attached to the shaft. The lead casting which houses the cylinder is covered with a thick brass shell, and is thereby attached to a bronze ring. Two steel studs are fastened to this ring at right angles to the cylinder, and these run on ball bearings in a steel yoke. The latter is suspended from a carriage rolling on the horizontal beam, and is capable of rotation on a vertical axis by means of a stout stud running on a ball bearing. In this way it is possible to adjust the beam of rays emerging from either opening in any desired orientation. As already mentioned, the horizontal steel beam can be moved up and down. The carriage can be rolled along this beam, and the table, on which the patient lies during the treatment, can be moved longitudinally on tracks placed at right angles to the steel beam. Thus with this arrangement it is a simple matter to place the heavy lead container (weighing about 500 pounds) over any desired part of the body in the proper orientation.

An ordinary set-up can be made in three minutes. Treatments last from one to several hours. A technician stays in an adjoining room and observes the patient every fifteen minutes through a small window in a lead-lined partition. This additional protection for the operator, and hospital personnel in general, is necessary on account of the radiation which is scattered by the patient's body and other matter in the path of the beam of rays.

GIOACCHINA FAILLA, *Physicist*

THE NATIONAL FORESTS AREA

THE total area of the national forests was increased by 41,214 acres in the last fiscal year, according to the latest check just completed by the Forest Service.

The aggregate net area of national forests on June 30, the close of the last fiscal year, was 158,800,424 acres. Included within the boundaries of the national forests was a gross area of 183,938,106 acres, of which 25,137,682 acres was alienated land.

With the separation of the Ocala National Forest, formerly a division of the Florida National Forest, as a distinct unit by recent proclamation of the president, there are now 160 national forests in the country, located in 32 states and in Alaska and Porto Rico.

The total net gain in area of national forests last year was not as large as the gain in several preceding years. This was due in part to the fact that a considerable acreage was transferred by special acts of the congress to national parks. The forests also were drawn upon to some extent in the consummation of state exchanges and consolidations. Net reductions in area were shown in the following states and territories: Alaska, 2,780 acres; California, 193,164 acres; Colorado, 19,399 acres; Nevada, 412 acres; New York, 6,154 acres (this reduction being due to the release of Camp Upton Military Reservation from national-forest status), and South Dakota, 1,776 acres.

The largest increase was 65,274 acres, this in Pennsylvania. Washington was second with a net increase of 63,084, followed by Wyoming with an increase of 42 494 acres, Georgia with 34,967, New Mexico with 27,084, Oregon with 21,852, Arizona with 20,230 and others with smaller amounts.

Up to the close of the last fiscal year lands acquired for national forests in the Eastern and Southern States under the Weeks law amounted to 2,564,619 acres, and an additional 328,122 acres has been approved for purchase.

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By KARL SUDHOFF, M.D.

Professor of History of Medicine in the University of Leipzig, 1895–1924.

Translated by various hands and edited, with foreword and biographical sketch,

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